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CORROSION ZONES IN CARBONATE ROCKS

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Corroded surfaces apparently of a diastemic nature have long been known from Middle Ordovician rocks in the upper Mississippi Valley. Their appearance in the field has not been described adequately, and no illustrations have been published. Because the writer believes that corrosion zones are present in rocks of similar age in other parts of the country, he hopes that this discussion will encourage search for them.

Corrosion zones probably were recognized first by T. C. Chamberlin in the Platteville formation of Wisconsin (Sardeson, 1898, p. 322). Sardeson (1898, 1914, 1926, 1937) discussed occurrences in the upper Mississippi Valley,but devoted most of his attention to corrosion conglomerates. Agnew (1948) referred to a "pitted erosional surface of disconformity" with associated phosphates at the top of the Platteville formation where the overlying Spechts Ferry member is absent (this may correspond to the phosphatic pebbles described by Bain, 1906). Templeton and Willman (1952) mention a corrosion zone near the top of the Pecatonica member of the Platteville formation in northern Illinois. The petrography and petrology of corrosion zones and the associated phosphates was rather fully treated by Pettijohn (1926).

Corrosion zones have been identified at several horizons in the Ordovician rocks of southeastern Minnesota (Weiss, 1953). The top of the Pecatonica member of the Platteville formation is marked by a group of three corrosion zones. Where the member approaches a feather edge toward the northwest only two can be identified with certainty, and it is not known what becomes of them beyond the limit of the member. Toward the southeast, where the member is several feet thick, there are two more corrosion zones near the middle and base of the member. Near the base of the McGregor member of the Platteville there is another corrosion zone. Where this member is underlain by the Pecatonica this corrosion zone maintains a constant interval of four feet above the top of the Pecatonica. A pair of closely-spaced corrosion zones was found in the lower part of the Galena formation at one outcrop. The uppermost part of the Prosser member of the Galena contains as many as six corrosion zones at one locality. Elsewhere there are fewer and these are grouped closely together. In each case the uppermost corrosion zone closely approximates the change from limestone to dolomitic limestone that characterizes the Prosser- Stewartville contact.

Corrosion zones appear in the field as smooth, irregular, or dove-tailed blackened intervals of wide lateral extent. Where fully developed (fig. 1, 2) they display a relationship that cannot possibly have originated other than by partial solution of the lower bed and subsequent deposition of the upper bed without destruction of the pitted surface. Such dove-tailed contacts may, however, grade

laterally into rather smooth blackened contacts for part of their extent along the outcrop. The character of these surfaces on planes parallel to their bedding is well shown in fig. 4. The black stain associated with corrosion zones results largely from finely divided pyrite, but partly also from small amounts of manganese oxide (Stauffer, 1925).

In addition to the color and irregularity of the surface, corrosion zones may show one or more of the following features; 1) a change of rock from below to above, 2) an increase of detrital material from below to above, sometimes with an influx of sand, 3) the presence of abundant collophane above the corrosion surface, in the form of tiny castings (?) , organic fragments, small flakes,and rounded or irregular polished granules and pebbles, and 4) corroded pebbles of the subjacent rock apparently suspended in the superjacent matrix (fig. 5). The lowest of the three corrosion zones at the top of the Pecatonica member (fig. 1, 2, 3) is overlain by abundant collophane and quartz sand, whereas the rock immediately under it is nearly free of both. The uppermost of the same group of three corrosion zones (fig. 2, 3) is coated with unusually large amounts of pyrite, the blackened crust containing up to 40 percent of that mineral.

Corrosion zones weather readily to a shaly, rust-colored slot in the outcrop (fig. 2), and are therefore difficult to identify in old exposures.

Hudson (1910) illustrated a surface much like that of figure 4 apparently in the process of formation today. He ascribed its formation in the Ordovician limestones of Valcour Island to gentle selective erosion of the shelving bedrock beach. He believed that the ridges of siliceous limestone that are the harder parts of the rock were formed by "vibration" waves on the Ordovician sea bottom. No such anisotropism of hardness and composition appears to be present in the limestone beds underlying the corrosion zones studied in Minnesota. Other etched surfaces figured by Hudson (1909) are pitted by cupholes, and do not resemble corrosion surfaces so closely.

If the Valcour Island occurence is really a corrosion zone in the process of formation it is doubly remarkable, inasmuch as such features could readily be produced during diagenesis in sediments just stiff enough to hold their shape during deposition of the overlying material. In the Minnesota occurrences no evidence was seen of distortion of the irregular surface by the later sediments. Retardation or lack of deposition, coupled with solution, is the only means by which these surfaces could be produced. They are therefore diastems, but the hiatuses must be very small because of the close similarity of the faunas above and below each corrosion zone. Pettijohn's statement (1926, p. 363) regarding the coincidence of corrosion zones with faunal zone boundaries is not true of the corrosion zones here considered.

The literature of corrosion zones is diffuse, and there is good reason to suspect that they have not always been recognized for what they are. It seems likely that

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EXPLANATION OF FIGURES

FIGURE 1. Ideal specimens of the lowest corrosion zone of a group of three at the top of the Pecatonica member of the Platteville formation; quarry near Mabel, Minnesota (SE cor. Sec. 15, T. 101 N., R. 8 W.). The specimen at the left is five inches tall.

FIGURE 2. View of the three closely-spaced corrosion zones at the top of the Pecatonica member of the Platteville formation in the wall of the quarry at Mabel, Minnesota (SE Cor. Sec. 15, T. 101 N., R. 8 W.). The middle and upper zones are obscured by weathering.

FIGURE 3. Group of three closely-spaced corrosion zones at the top of the Pecatonica member of the Platteville formation exposed in the quarry at the RR overpass west of Spring Grove, Minnesota (SE¼ SE¼ Sec. 17, T. 101 N., R. 7 W.). The pencil lies between the middle and upper zones, the latter of which is heavily charged with pyrite or marcasite.

FIG. 1

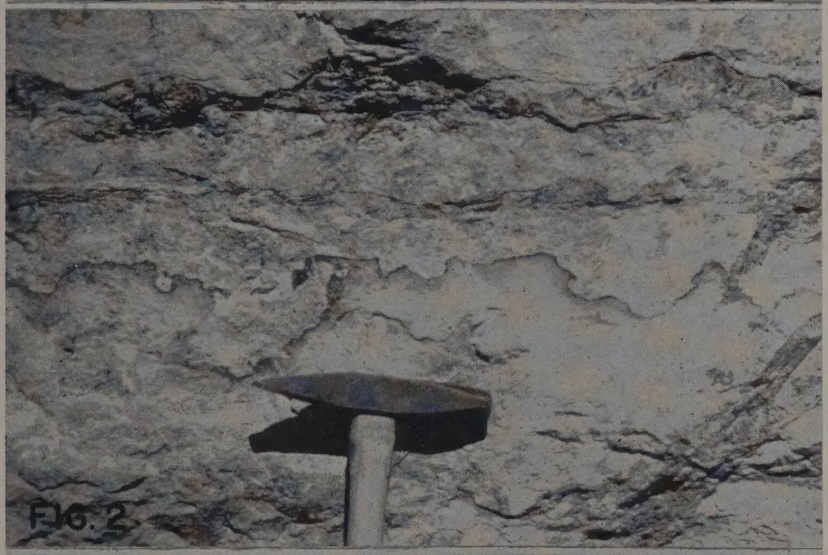
FIG. 2

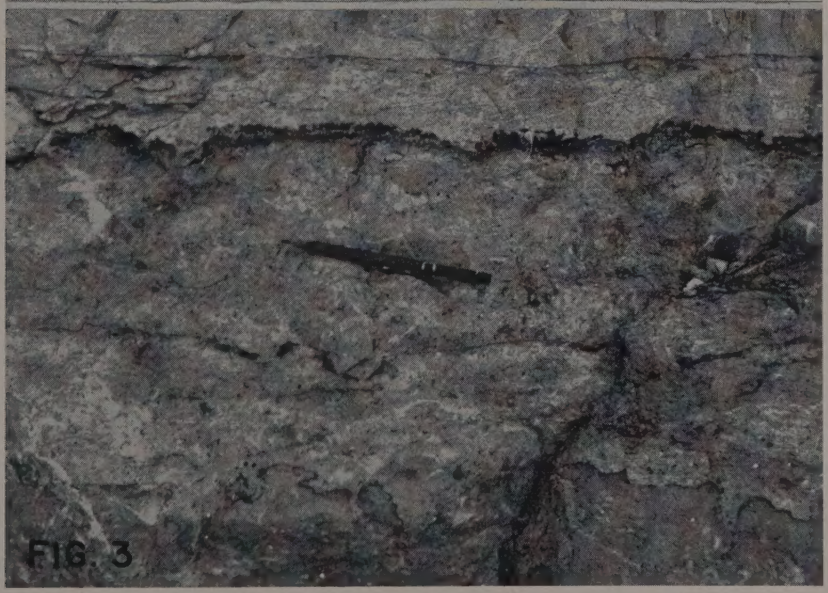
FIG. 3

these features are more widespread than has been realized heretofore. The peculiar contact between the Lebanon and Carters limestones in central Tennessee, illustrated by Bassler (1932), has the appearance of a typical corrosion zone. The feature is not described in the text, except for a reference to the color difference in the measured section on page 29. If corrosion zones are really present in Tennessee they may be found in other eastern states in rocks of similar age.

Corrosion zones can be useful stratigraphic tools in the study of Middle Ordovician rocks, at least within regions like the upper Mississippi Valley. Even within these limits their potential value justifies much closer study of these features than they have received in the past. But the possibility that corrosion zones occur widely in Ordovician rocks and also in rocks of other ages should encourage widespread search for them. For these reasons the writer has attempted to direct attention again to these features of carbonate rocks.

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EXPLANATION OF FIGURES

FIGURE 4. Block showing the underside of a surface intersecting the lowest of a group of three corrosion zones at the top of the Pecatonica member of the Platteville formation; quarry at the RR overpass west of Spring Grove, Minnesota (SE¼ SE¼ Sec. 17, T. 101 N., R. 7 W.). The dark rock is below the corrosion zone and the light rock is above.

FIGURE 5. Group of three closely-spaced corrosion zones at the top of the Prosser member of the Galena formation seen in a loose block on the floor of the Masonic Park quarry near Spring Valley, Minnesota (SE¼ Sec. 11, T. 103 N., R. 13 W.). The knife lies between the middle and upper zones. The weathered slot between the two lower zones is apparently not a corrosion zone. The lower zone shows some corrosion conglomerate.

FIG. 4

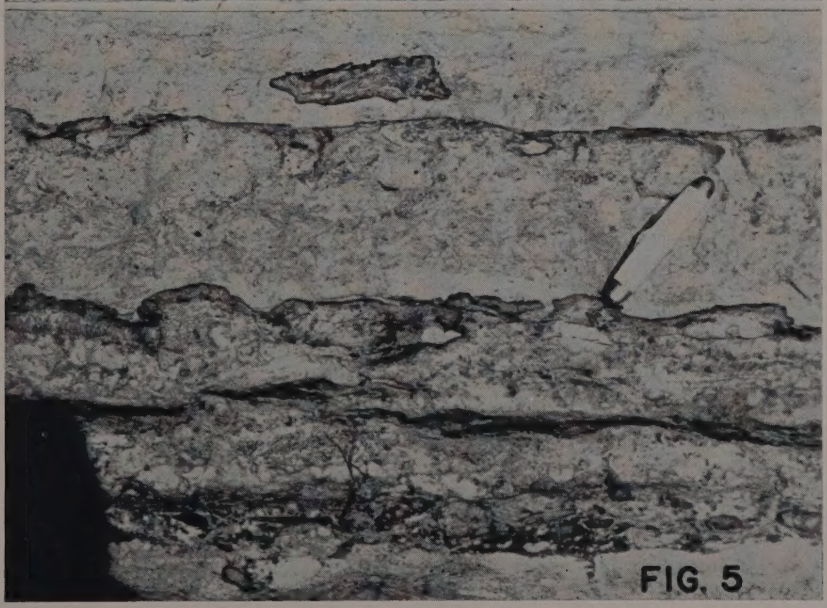

FIG. 5

TWO NEW NORTH AMERICAN BUPRESTIDAE WITH NOTE (COLEOPTERA)

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In my studies of the Buprestidae, the following species appear to be worthy of record. Type material in collection of author.

Trachykele fattigi n. sp.
Figure 2

Male.—Elongate, robust; dark bronze throughout; elytra with irregular black depressed areas beginning in front of middle and extending to apical fourth.

Head convex; surface irregular, with median carina on front and deep depression above clypeus, densely, irregularly, coarsely punctured; antennae extending to beyond hind angles of pronotum when laid along side, serrate from fourth segment, scape stout, second segment about twice as long as wide, third shorter than fourth, fifth and following segments including eleventh, gradually decreasing in length.

Pronotum much wider than long, widest about middle, wider at base than at apex; sides broadly rounded in front, strongly expanded about middle, acutely rounded to base; anterior margin sinuate, median lobe broad; basal margin truncate; disk uneven, with deep median depression in front of scutellum and a broader one back of apex, both connected by smooth area, one deep basal depression each side, a broad transverse depression each side on basal half and a lateral depression back of apex; surface densely, irregularly coarsely punctured. Scutellum not visible.

Elytra at base narrower than widest part of pronotum, wider than pronotum back of base; sides strongly rounded at base, subparallel to apical third, then broadly rounded to truncate apices; disk uneven, with three transverse basal depressions on each elytron, irregular sparsely punctured black depressions starting in front of middle and extending to apical fourth; surface densely, irregularly, coarsely punctured.

Surface beneath coarsely, densely punctured including first segment of abdomen, following segments densely, finely punctured, a smooth area each side on first four abdominal segments; last visible sternite truncate at apex.

Tarsi not quite as long as tibiae; first segment of hind tarsus much longer than second, second longer than third, third longer than fourth.

Length 15.8 mm., width 5.4 mm.

Described from a specimen collected from juniper (*Juniperus*) at Stone Mountain, Ga., April 10, 1951 by Lucine Harris, Jr.

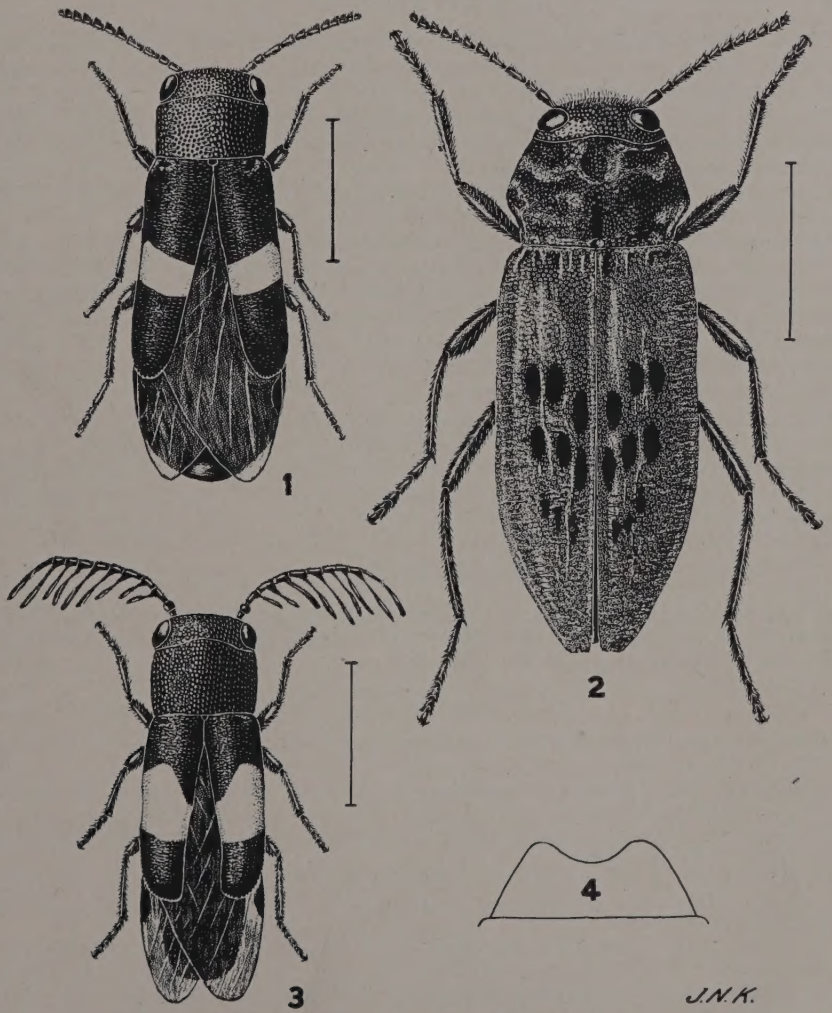
This species should stand next to *T. blondeli blondeli* Mars. The dark bronze color, more broadly rounded elytral apices and arrangement of the dark depressed areas of elytra will distinguish it fom the above species. A. Descarpentries kindly compared a specimen of *blondeli blondeli* with Marseul's type. I am indebted to the late P. W. Fattig for presenting me with this beetle.

Hesperorhipis jacumbae n. sp.
Figures 1, 3, 4

Male.—Narrow, elongate; head and pronotum dark blue; elytra dark purple, each elytron with a large white area about middle, with anterior margin extending forward diagonally from suture to outer margin, curved backward near margin, margin on the rear extending from sutural margin diagonally forward to outer margin; beneath dark blue; mouth parts, outer portions of legs and antennae dark brown.

Head convex, slightly impressed on upper part of front; surface coarsely reticulately punctured; antennae extending past middle of elytra when laid along side, flabellate, rami beginning with third segment, scape stout, second segment wider than long, wider than scape.

Pronotum wider than long, about as wide at base as at apex; anterior margin sinuate, median lobe prominent, basal margin slightly sinuate; sides subparallel, disk convex; surface roughly reticulately punctured. Scutellum transverse, depressed.



1. *Hesperorhipis jacumbae* n. sp. ♀, (line equals 1 mm.).
2. *Trachykele fattigi* n. sp. ♂, (line equals 5 mm.).
3. *Hesperorhipis jacumbae* n. sp. ♂, (line equals 1 mm.).
4. Last visible sternite of number 3, enlarged.

Elytra back of base slightly wider than pronotum, elytron wider at base than at apical third, short, three entire visible ventral abdominal segments extending beyond apices; sides subparallel near base, constricted about middle, wider back of middle then broadly rounded to apices; lateral

margins serrulate from basal fourth; sutural margins converging posteriorly, sinuate back of middle; disk slightly convex, posterior portion of white area on each elytron depressed, giving apical fourth a tumid appearance; surface of dark part rugose, punctures indistinct, white area much smoother; wings extending beyond apex of abdomen

Abdomen beneath shining, coarsely punctured, last visible abdominal deeply emarginate. Side of metasternum with a large pubescent depression. First segment of hind tarsus as long as two following combined, third and fourth segments lobed beneath.

Length 2.6 mm., width .8 mm.

Female.—Head and pronotum shining; dark blue; pronotum with a brassy tinge; elytra dark purple, shining blue at base, with obliquely transverse white area about middle; beneath dark blue; abdomen with brown areas.

Head less coarsely sculptured than male; antennae not flabellate, serrate from fifth segment, scape stout, second segment longer than wide, wider than scape, third shorter than scape, following segments gradually decreasing in length.

Elytra short, three visible ventral abdominal segments extending beyond apices; sides of each elytron converging toward apex, not sinuate on sutural margin.

Metasternum without depression. Last visible sternite rounded, densely pubescent at apex.

The males of this species are close to *H. hyperbolus californicus* Knull. It lacks the brilliant blue on head, pronotum and base of elytra on *hyperbolus hyperbolus* Knull and *californicus* and ventral surface is less coarsely sculptured. The white area on elytron is more extensive than on *albofasciatus* Fall. The emargination of last sternite is deeper and not as wide as it is in *mirabilis mirabilis* Knull and *mirabilis albopennis* Knull. The elytra of the latter two forms are much shorter.

Genus *Hesperorhipis* as defined by Fall (1930) appears to correspond to *Xenorhipis* to some extent. The large hairy depression on side of metasternum which Fall states is lacking in *Hesperorhipis* is present on the genotype and was evidently overlooked by the describer. I have considered the species with third segment of antennae ramose and with posterior coxal plates triangular in ♂ as belonging in *Hesperorhipis*.

Mastogenius antennatus Caz.

This species should be added to our Catalogue of Coleoptera of America North of Mexico. Specimens are at hand from Long Key, Fla., May 15, 1939, D. J. and J. N. Knull and Monroe Co., Fla., April 28, 1953, N. J. and E. L. Sleeper.

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AUDIO-SPECTROGRAPHIC ANALYSIS OF THE SONG OF THE CONE-HEADED GRASSHOPPER, *NEOCONOCEPHALUS ENSIGER* (HARRIS)

(ORTHOPTERA: TETTIGONIIDAE)

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The song of *Neoconocephalus ensiger* has been described as consisting of a rapid series of somewhat lisping notes that sound like *chwi* (Scudder 1874), *tsip* (Allard 1911) , or *zick* (Cantrall 1943) . Pierce (1948, p. 195) states that the notes have a frequency of 13,700 cycles per second (a pitch very near the second A above the highest note on the piano), and are 0,033 sec. in length separated by silent intervals 0.052 sec. in length. This writer cannot hear frequencies as high as 13,700 cps, yet has no difficulty in hearing the song of this insect; it would thus appear that something is wrong with Pierce's figure of 13,700 cps.

On August 24, 1953, a male of this species was collected in a grassy field in Bremen Twp., Lincoln Co., Maine; the insect was caged and later the same day a recording was made of its song. The recording was made with a Magnemite tape recorder, using a tape speed of 15 in. per sec; the insect was about 8 in. from the microphone. The specimen and the recording are in the writer's collection.

THE AUDIO-SPECTROGRAPH

The audio-spectrograph used in this study was a Vibralyzer, which was made available to the writer through the kindness of Dr. J. Allen Hynek, of the Department of Physics and Astronomy, The Ohio State University; the writer is indebted to Mr. William M. Protheroe, of the same department, for assistance in the operation of this instrument. The nature and use of the Vibralyzer is described by Borror and Reese (1953) .

Two types of graphs can be made with the Vibralyzer. In one type frequencies are portrayed on the vertical axis and time on the horizontal axis, and variations in intensity appear as corresponding variations in the darkness of the mark on the graph. A second type of graph, called a section, shows (for any selected point in time) frequencies on the vertical axis and intensity on the horizontal axis. The graphs are made electrically on facsimile paper; frequencies are portrayed over a vertical distance of about 4 in. and time over a horizontal distance of 12½ in. The frequency range of the instrument, and the degree of time and frequency resolution, depend on the tape speed of the recorded signal fed into the instrument, and on the settings on the instrument. With the proper settings, frequencies can be determined from the graphs with an accurancy within 2 percent of the frequency range covered by the graph.

RATE OF PRODUCTION OF THE NOTES

The notes in the song of *N. ensiger* are uttered too rapidly to count, but can be counted if the recording is played at a reduced tape speed. Two sections of the song were recorded; in the first section the song is continuous, but in the second there are two places where the insect paused momentarily between notes; the three portions of the second section which are set off by these pauses may be designated 2a, 2b, and 2c. Data on the number of notes and their rate are given in table 1.

FREQUENCIES IN THE NOTES

Figure 1 is a graph of 20 successive notes in the first section of the recording. It is evident that the frequency distribution in each note is continuous within

the range of the graph (40 to 4,500 cps); the abrupt cut-off at the top of the graph suggests that the notes contain frequencies higher than 4,500 cps. The various notes are by no means exactly alike as regards the relative intensities of the different frequencies within this range, but the rate with which the notes are uttered is quite regular.

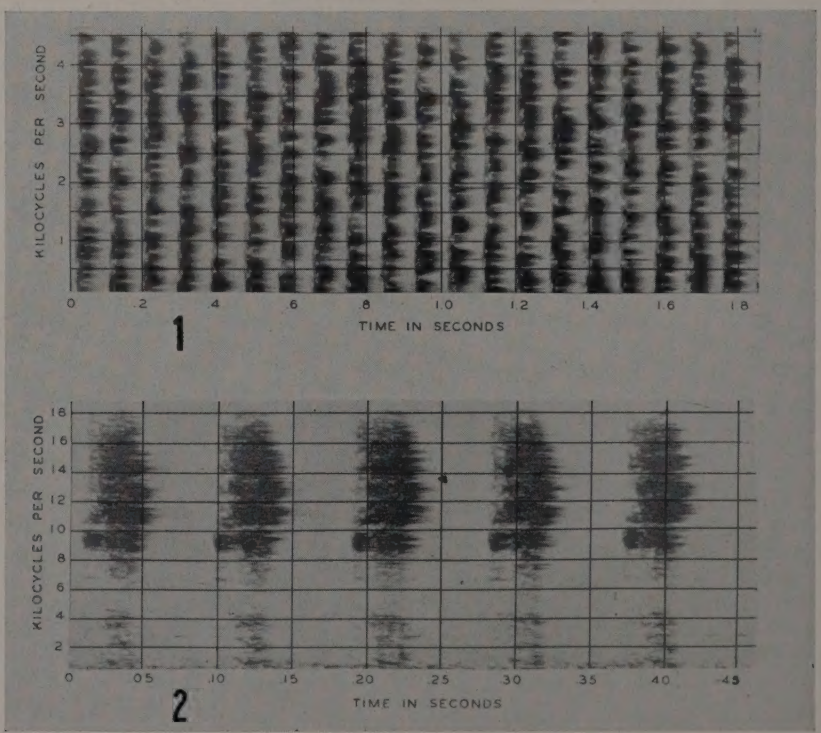
Figure 2 shows five successive notes in the first section of the recording; this graph was made to bring out a greater range of frequencies than is shown in figure 1. While there are weak frequencies below 8,000 cps, the most intense frequencies in each note lie between approximately 8,500 and 17,500 cps. Practically all frequencies between 8,500 and 17,500 are present, but there are four or five groups

TABLE 1

Rate of the notes in the song of N. ensiger

Section	Number of Notes	Length (sec.)	Notes per Second	Average Length of Note + Interval
1	513	45.60	11.25	0.089 sec.
2a	321*	29.55	10.86	0.092 sec.
2b	177*	16.30	10.86	0.092 sec.
2c	124	11.25	11.02	0.091 sec.
Total	1135	103.70	10.95	0.091 sec.

*Each long note and double note (see fig. 8) was counted as one note.

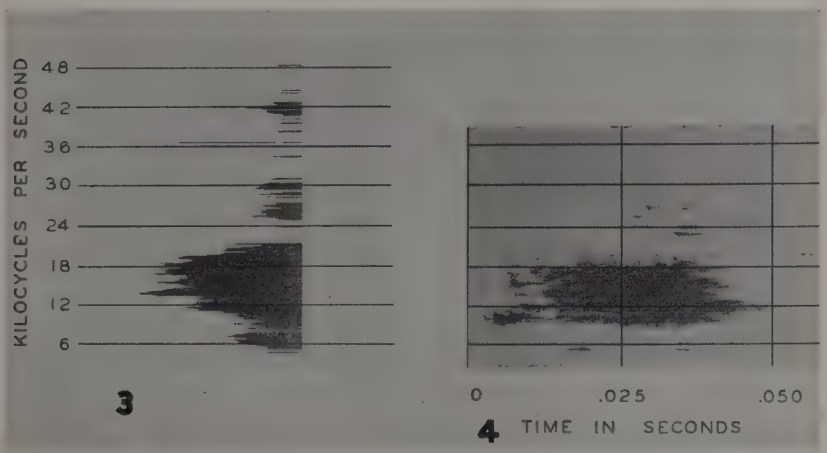


FIGURES. 1–2. Audio-spectrographs of the song of *N. ensiger*. These graphs were made to give a maximum degree of frequency resolution; both were made from the first section of the recording. The difference in the darkness of the mark below 4,500 cps in the two figures is due to the different instrument settings when the graphs were made.

of more intense frequencies in this range. Again, the successive notes are very much alike, though not absolutely identical.

Figure 4 shows a single note, and covers a much greater frequency range than either of the first two figures. Here the most intense frequencies appear to consist of a band between about 9,000 and 18,000 cps. Frequencies below 4,500, distinctly shown in figure 1, are barely perceptible in figure 4; an instrument setting which gives a good graph for the more intense frequencies between 9,000 and 18,000 cps scarcely shows the frequencies outside this range. This graph does not portray a very wide range in intensity, but it suggests that there are frequencies in the note much higher than 18,000 cps.

By making a section graph through one of these notes it is possible to portray a greater range in intensity than is possible in a graph like that in figure 4. Such a section, taken at about the middle of a note, is shown in figure 3. The length of the mark at any given frequency level in this figure is proportional to the decibel value of that frequency. Additional data will be needed before a definite decibel value can be given for any particular note or frequency. Figure 3 shows that the note contains frequencies up to almost 50,000 cps.



FIGURES. 3–4. Audio-spectrographs of the song of *N. ensiger*, made from the first section of the recording. Figure 3 is a section through the middle of a note. Figure 4 has the same frequency scale as figure 3.

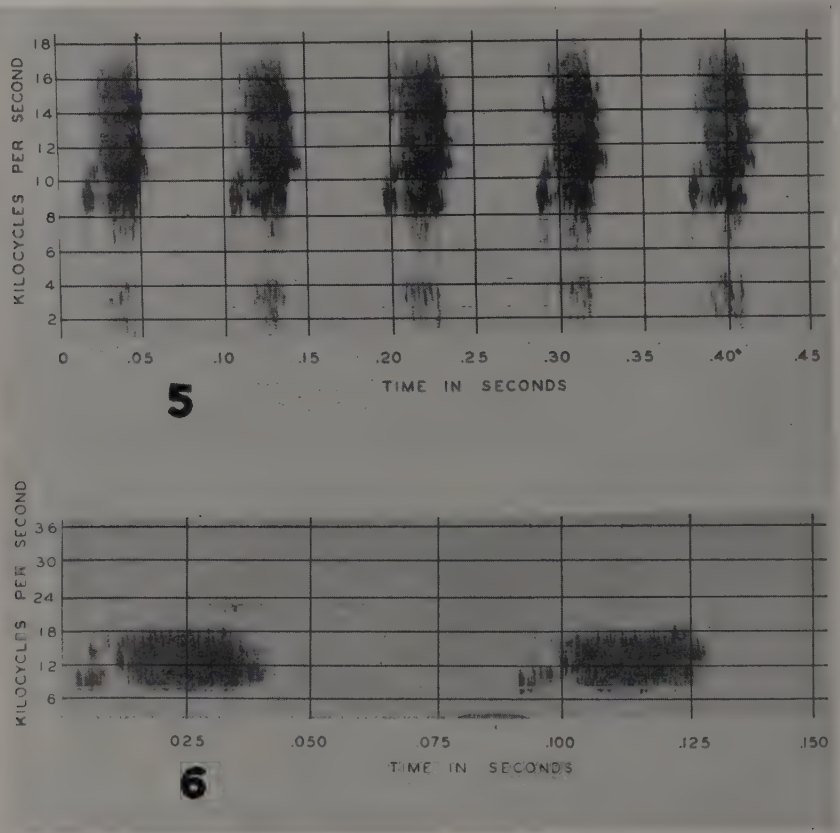
Since the notes of this insect contain a wide band of frequencies they are noise-like rather than musical, that is, they cannot be assigned a particular pitch. How they sound to the ear will depend on how well that ear can detect the higher frequencies present. To this writer, whose hearing falls off very rapidly above about 10,000 cps, the notes sound somewhat rasping; to a person with a normal hearing range (up to 15,000 or 16,000 cps) the higher frequencies will be more evident, and the notes will sound more lisping. The figure of 13,700 cps given by Pierce (1948) probably represents an average of all the frequencies present. Pielmeier (1946), using a sound level meter in which the frequencies measured could be varied, found no output peaks above 20,000 cps in the song of this species. Figure 3 indicates that the intensity of the frequencies above 20,000 cps is quite low, in general lower than that of the frequencies below 8,000 cps.

LENGTH AND CHARACTER OF THE NOTES

The graphs in figures 1 to 4 were made using a narrow band filter, to give maximum frequency resolution; the remaining figures were made using a wide band filter, to give maximum time resolution.

Fig. 5 shows that the individual notes are not steady tones, but consist of a very rapid series of pulses. Each note begins with a series of pulses whose most intense frequencies lie between about 8,000 and 11,000 cps, as shown by the little "blurb" at the lower part of the dark area representing the note's loudest frequencies. One second covered about 22 in. on the original of this graph.

Figure 6 shows two successive notes in the first section of the recording; here we have a high degree of time resolution, with about 66 in. on the original graph representing one second. The "blurb" at the beginning of each note is shown more distinctly here. A number of graphs of this sort were made, and the indi-



FIGURES. 5–6. Audio-spectrographs of the song of *N. ensiger*, made from the first section of the recording. These graphs were made to give a maximum degree of time resolution.

vidual notes varied in length from 0.037 to 0.041 sec., averaging 0.039 sec. Since the average length of the note plus the interval between notes is 0.091 sec. (table 1), the interval therefore averages 0.052 sec. (the same figure given by Pierce). The pulses in the note are slightly irregular, but there are about 40 per note.

THE MECHANISM OF SONG PRODUCTION

When this insect sings the front wings are elevated slightly and moved laterally (outward and inward), at a rate that is too fast to count or to determine what part of the movement actually produces the notes. The notes are produced by the

rubbing of the scraper of one wing (a specially modified portion of the anal edge of the wing) over a file-like ridge on the other wing. There is a file on both wings, but since the file is on the lower surface of the wing, and at rest the base of the left wing overlaps the base of the right wing, apparently only the file on the left wing is used in producing the song.

The file on the left wing is a little over 3 mm. in length and contains about 100 teeth; one wing studied contained 100 teeth in 3.2 mm., and Pierce (1948 p. 195) gives the figure of 108 teeth in a file 3.15 mm. in length. The file on the right wing is shorter and contains about 70 teeth. The teeth of the file on the left wing are not evenly spaced; they are somewhat closer together in the inner (or posterior) half of the file than in the outer half, and the teeth from about the fifteenth to the twentieth from the outer end are somewhat closer together than those adjacent to them. The teeth project from the wing at about a right angle; the inner side of each tooth is nearly straight, while the outer side is slanted.

How much of this file is used to make a note is not known. It was stated above that each note contained about 40 pulses; it seems probable that each of these pulses represents a tooth being struck. If this is the case, then only about 40 percent of the file teeth are used in making each note, and the teeth are struck at the rate of from 1,000 to 1,200 per second[1], with the scraper moving at the rate of about 2½ in. per sec.

An interesting question might be raised at this point—is it the outward or the inward movement of the wings that produces the sound, or do both movements produce it? Allard (1929) and others believe that the notes are made only by the inward movement, but to the writer's knowledge this never been conclusively demonstrated. Information on the rate of the wing movements during singing would help to answer this question, but such information is not at present available; perhaps some light may be thrown on this question by a consideration of audio-spectrographs of the song and the structures by which the song is produced.

If the pulses in each note represent individual teeth being struck, then only about 40 percent of the teeth in the file are struck in producing each note. Of the total time from the beginningof one note to the beginning of the next—about 0.09 sec. (table 1)—the note itself takes on the average 0.039 sec., or just a little over 40 percent. If the scraper moves from one end of the file to the other and at a uniform rate (and this is certainly a big "if"), it would appear that the note is produced during that portion of this movement when the scraper hits the teeth of the file This would not allow any time for return movement of the wings without sound, and would indicate that a note is produced by *both* the outward and inward movements of the wings.

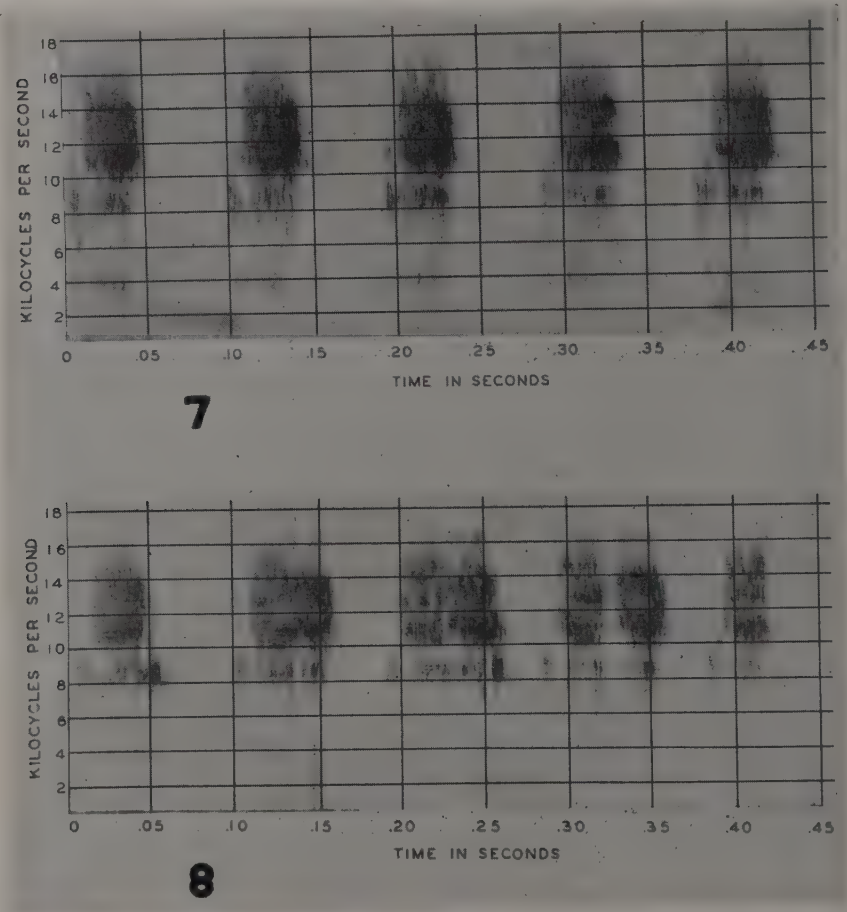
It seems likely that the insect would stop singing with its wings in a closed position, hence if a note is produced by both the outward and inward movements of the wings then each period of song would contain an even number of notes. Only one portion of our recording can possibly be considered a complete period of song, namely, section 2b. This section contains an *odd* number of notes (177), which might indicate that the notes are *not* produced by both movements. However, the silent interval at either end of section 2b is very short, about 0.1 sec., or only about twice the usual interval between notes; hence this section may not represent a complete song period of the insect.

The shape of the file teeth suggests that if a note was produced by both the outward and inward movements of the wings, these two notes would probably be slightly different. In the graphs discussed so far, which were made from the first section of the recording, there is no indication that alternate notes are more alike than successive notes; the notes are all essentially alike. It would thus

[1]Pierce's figures (op. cit., p. 196) on the number of teeth struck per second range from 286 to 875, averaging 588, a figure Pierce believes to be too high.

seem that either all the notes are made by the scraper moving in the same direction, or that in spite of the shape of the teeth both movements of the wings (outward and inward) produce a similar sound.

If it is assumed that each note is made by the scraper moving in the same direction over the file, with the backstroke silent, it might be argued that since the wing movements are so fast and the clearance between scraper and file on the backstroke probably small, the scraper might occasionally hit the file on the backstroke. If this occured, then we would get an extra note, and the extra note



FIGURES. 7–8. Audio-spectrographs of the song of *N. ensiger*, made from section 2b of the recording. Figure 7 shows a series of normal notes; the series shown in figure 8 contains three unusual notes.

might be expected to be a little different from the preceding and following notes. Furthermore, if such backstroke notes were produced we would expect them to be irregular, and this contact of the scraper with the file on the backstroke would probably slow down the wing movements and result in a slightly slower rate of the regular notes.

There is no indication of such "backstroke notes" in sections 1 and 2c of our recording, but in sections 2a and 2b there are. The note rate in these two sections

(see table 1) is slightly lower than that in the other two sections. There are several examples of such notes in section 2a and 2b; figure 8 shows some from section 2b. A group of normal notes in section 2b is shown in figure 7; figures 7 and 8 were made with similar instrument settings for ready comparison.

The second and third notes in figure 8 are longer than usual, and the fourth note is double. The little "blurb" at the beginning of the normal notes appears also at the *end* of the second part of the third and fourth notes (fig. 8, at the .25 and .35 sec. lines), where it is stronger than the "blurb" at the beginning of the first part of these notes. There is no very distinct break in the middle of the second long note, and practically no break at all in the first long note; if these two long notes represent both the normal stroke and the backstroke, then the wings were stopped and reversed almost instantaneously.

There is another possible explanation of the long and double notes shown in figure 8. In the case of the long notes, it is possible that the scraper simply struck more file teeth than usual; the absence of a distinct break in the middle of the note suggests this possibility. In the case of the double notes it may be that the scraper "bounced," and for some reason the last teeth struck were struck harder than the others, thus producing the little "blurb" at the end of the double note.

SUMMARY

A tape recording of the song of *Neoconocephalus ensiger* (Harris) was analyzed by means of an audio- spectrograph. The song consisted of a series of similar notes uttered at the rate of 10.86 to 11.25 (average 10.95) per sec., the notes averaging 0.039 sec. in length. The notes in most of the recording were very much alike, and each consisted of about 40 pulses; these pulses probably represent individual teeth of the file being struck. The notes are noise-like rather than musical, and contain a wide band of frequencies; the most intense frequencies lie between about 8,000 and 17,500 cps, but each note contains a band of frequencies below this range down to at least 40 cps, and frequencies above this range to nearly 50,000 cps.

Each note of the song is probably produced by one movement of the scraper of the right wing over the file of the left wing. The length of the note and the number of teeth struck, in relation to the length of the silent interval between notes and the total number of teeth in the file, suggest that a note may be produced by both the outward and inward movements of the wings. On the other hand there are indications that only one of these movements produces the note; (1) what appears to be a complete period of song contains an odd number of notes, and (2) the structure of the file teeth suggests that the notes made by the scraper moving in different directions would be different, yet the graphs indicate that successive notes are as much alike as alternate notes. The occasional long or double notes that appear in the song suggest that the scraper *does* occasionally strike the file on the backstroke, but that normal notes are made only by one movement of the wings.

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GEOMETRY OF THE TWO-CRYSTAL X-RAY SPECTROMETER[1]

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In order to avoid rather considerable gearing linkages the two-crystal spectrometer (Compton and Allison, 1934) is often arranged so that the x-ray tube, one of the crystals and the detector remain fixed while the other crystal is rotated through a small angle to scan the spectral region under study. The limitation on the spectral region which can be scanned at one such setting is imposed by the size of the crystals and of the detector opening. As either the first or the second crystal is rotated the region of Bragg reflection moves across the crystal surface. As shown later on, this "walking" turns out to be considerably larger when the first of the two crystals is rotated.

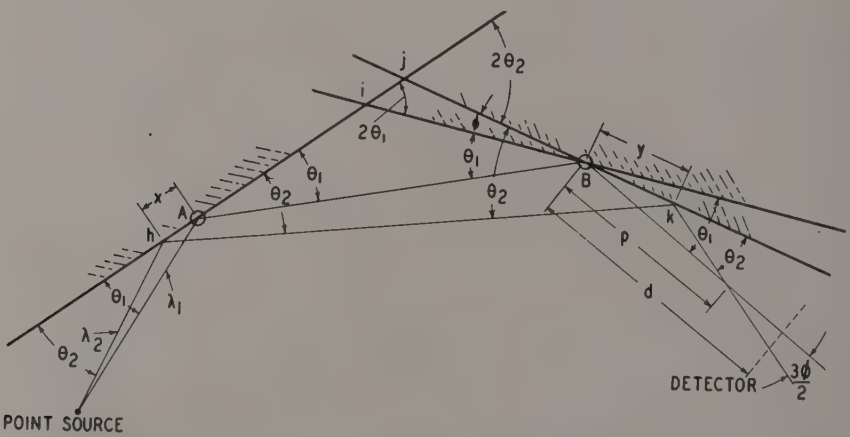

Figure 1. Rotation of *second* crystal. Ray paths through the two-crystal spectrometer for wavelengths λ_1 and λ_2; ($\lambda_2 > \lambda_1$); A and B are fixed axes of rotation of the first and second crystals respectively.

In figure 1 are shown two crystals whose reflecting faces are perpendicular to the page and whose fixed axes of rotation are at A and B. The ray λ_1 is reflected at Bragg angle Θ_1 while the ray λ_2 of somewhat longer wavelength is reflected at Bragg angle Θ_2 after rotation of the *second* crystal through a small angle ϕ while the first crystal remains fixed. It is clear that the second ray will be reflected from points h and k different from A and B. It is the purpose of this paper to investigate the walking of the central ray as either the first or second crystal is rotated. The discussion is limited to central rays.

Simple geometrical considerations of figure 1 show that

$$\Theta_2 = \Theta_1 + \phi/2$$

$$Ah = x = L \frac{\sin \phi/2}{\sin (\Theta_1 + \phi/2)},$$ where L is the distance from the source to the first axis A; and

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[2]Du Pont Fellow, 1952–53.

$y = Bk = x + \frac{S}{2\cos\theta_1}\left[1 - \frac{\sin 2\theta_1 - \sin\phi}{\sin(2\theta_1+\phi)}\right]$, where S is the separation between the axes, A and B. If we define p to be the distance from the second axis B to the intersection of the rays, then

$$p = y\,\frac{\sin(\theta_1+\phi/2)}{\sin 3\phi/2}.$$

When a detector is located at a distance d from the second axis, the walking, w, of the beam on the detector is given by

$$w = (D\text{-}p)\sin 3\,\phi/2, \text{ or } w = y\sin(\theta_1+\phi/2) - D\sin 3\,\phi/2.$$

Table 1 shows representative values for the walking for three values of θ_1 and four values of $\phi/2$. The values of L, S and D were chosen as being fairly typical. The walking on the crystals is seen to be independent of crystal parameters and of x-ray wavelength, depending only on the Bragg angle and the dimensions of the spectrometer.

TABLE 1

Distances in Inches ($L=12$ *in.*; $S=8$ *in.*; $D=4$ *in.*)

θ_1	$\frac{\phi}{2}$ $(=\Delta\theta)$	x	y	w
	15′	.572	.954	.035
	30′	1.093	1.821	.070
5°	1°	2.003	3.339	.140
	1°30′	2.775	4.629	.210
	15′	.104	.173	.035
	30′	.206	.344	.070
30°	1°	.407	.678	.140
	1°30′	.601	1.002	.210
	15′	.068	.113	.035
	30′	.136	.226	.070
50°	1°	.269	.449	.140
	1°30′	.401	.669	.210

At Bragg angles greater than 30° and less than 75° and for $\Delta\theta \leqslant 1°30'$ the following simple linear formulas can be used with an error of less than 5 percent.

$$x = L\,(\phi/2)\csc\theta_1$$
$$y = (L+1.05\,S)\,(\phi/2)\csc\theta_1$$
$$w = (\phi/2)\,(L+1.05\,S-3D).$$

Figure 2 shows the geometry when the first crystal is rotated. θ_1, θ_2 and ϕ are defined as before. It follows that

$$\theta_2 = \theta_1 - \phi/2$$
$$Ah = x = L\,\frac{\sin 3\,\phi/2}{\sin(\theta_1-\phi/2)}$$
$$Bk = y = x - S\left[\frac{\sin\theta_1 - \sin(\theta_1-\phi)}{\sin(2\theta_1+\phi)}\right]$$

and

$$p = y\,\frac{\sin\theta_1}{\sin\phi/2}.$$

The walking across the detector is given by

$$w = (D\text{-}p)\sin\phi/2, \text{ or}$$
$$w = y\sin\theta_1 - D\sin\phi/2$$

Table 2 shows representative values for the walking. The same values of L, S and D were used.

An approximate formula useful as before for Bragg angles between 30° and 75° and for small $\Delta\Theta$ is

$$x = 3\ L\ \csc\ \Theta_1\ (\phi/2)$$

For this case, no simple approximations to y and w similar to those of the first case are possible.

TABLE 2

Distances in Inches ($L=12$ in.; $S=8$ in.; $D=4$ in.)

Θ_1	$\frac{\phi}{2}$ $(=\Delta\Theta)$	x	y	w
	15′	1.897	1.515	.115
	30′	4.004	3.274	.250
5°	1°	9.003	7.663	.598
	1°30′	15.422	13.563	1.077
	15′	.316	.197	.081
	30′	.638	.402	.166
30°	1°	1.296	.835	.348
	1°30′	1.973	1.297	.544
	15′	.206	.148	.096
	30′	.413	.297	.193
50°	1°	.832	.600	.390
	1°30′	1.257	.910	.592

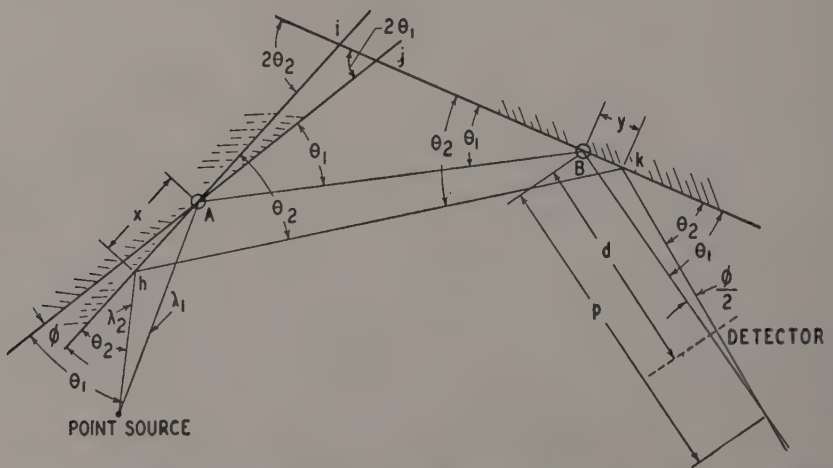

Figure 2. Rotation of *first* crystal. Ray paths through the two-crystal spectrometer for wavelengths λ_1 and λ_2; $(\lambda_2 > \lambda_1)$; A and B are fixed axes of rotation of the first and second crystals respectively.

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ANTARCTICA AS A CENTER OF ORIGIN OF BIRDS

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With the rapid evolution of reptilian forms during Triassic and Jurassic times, many reptilo-avian forms may have evolved. Two examples of such evolution have been preserved in the Jurassic sediments of Germany (*Archaeopteryx* and *Archaeornis*).

An anatomical feature, characteristic of birds, and not reported for either of these forms, is a well-developed sternum (Wetmore, 1951). Since this is an important avian characteristic, neither of these bird-like animals should be considered to be related directly to the ancestors of modern birds. Therefore, other yet undiscovered forms may be regarded as more properly comprising the Archaeornithes, and these ancestral forms may be found to have lived on the Antarctic continent at a time when that land supported a flourishing tropical vegetation and highly varied vertebrate fauna.

To explain the uniform presence of a very well-developed sternum in birds would be difficult if this structure were not already present in some ancestral reptile or amphibo-reptile. While a sternum is found in amphibians, there is no rib-sternum articulation comparable to that found in the known birds. Furthermore, the variation in rib-sternum apparatus in the reptiles is considerable and does not compare with the rib-sternum apparatus in any of the known birds. Recently, the view has been widely accepted that the carinate sternum preceded the non-carinate or ratite type of sternum. This latter view remains open to presentation of further substantiating evidences.

Since there is no apparent evidence of its presence in either *Archaeopteryx* or *Archaeornis* (Wetmore, 1951), it may be inferred that these forms are palaeontological curiosities which did not contribute to avian evolution, and that there may have been a great many other (undiscovered) unsuccessful reptilo-avian or avio-reptilian forms produced.

The occurrence of feathers in these animals may be regarded as another instance or example of paramorphogenesis and not one of convergent evolution. The capacity for flight is not restricted to birds, but is known to have been developed in reptiles and mammals as well as in birds.

It is possible that the fossil evidences of the true ancestral birds are to be found in or among the Jurassic coal deposits of Antarctica. It is likewise possible that the fossil remains of pro-mammalian forms, early Metatheria and Eutheria, are to be found in or among these same deposits.

PALAEOGEOGRAPHICAL INFERENCES

Most of Europe, Asia, Australia, Greenland, South America, and Antarctica are said to have had a tropical or sub-tropical climate during Jurassic time. Since the climate would have been generally favorable for the production and survival of many new land vertebrates, it may be inferred that the origin of pro- and quasi-avian and mammalian forms could have taken place in any one of these land masses.

Based on the neogeographical as well as the palaeogeographical distribution of the known orders of birds, and especially the relict orders, it is not entirely feasible to look for the center of origin in Asia or Europe, nor for that matter in either South America or Australia. While Greenland has been suggested as a center of origin, there have been too many objections to this view. Major objections to the Arctic region as a center of origin are readily found in the known distribution of birds.

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To assume that Greenland had been the center of origin for birds and mammals would make it more difficult to explain a pre-Miocene distribution of either Metatheria or Eutheria in South America, marsupials and monotremes in New Zealand and Australia, or the post-Miocene occurrence of tinamous and rheas in South America, and emus, cassowaries and kiwis in New Zealand and Australia. On the other hand, if we were to assume the origin of early birds and mammals to have taken place in Antarctica, the subsequent occurrence of these forms in seemingly widely separated and unconnected land masses (Australia and South America) could be accounted for by assuming that land connections existed between Antarctica and South America, and between Antarctica and Australia—during or subsequent to the period of evolution of these early birds and mammals. Such land connections would have been possible with a sea level lower than at present. This could have occurred during a period of extensive glaciation or during one of the great ice ages. Pauly (1952) has reported on the occurrence of such an ice age during Mesozoic time.

FIGURE 1. Probable routes of dispersal from Antarctica.
(Heavy solid lines = Primary dispersal routes.)
(Heavy broken lines = Secondary dispersal routes.)

According to Pauly (1952) a large part of southeast Africa was covered by a great ice and snow mass, while Antarctica was subjected to tropical and subtropical climates, during Jurassic time.

There are still some evidences of land connections in the form of small islands between these land masses. The land bridge to South America still is quite evident (Graham's Land, South Orkney, South Shetland, and Faulkland Islands). The land bridge to Australia and New Zealand is less evident today than that with South America.

In addition to these two land bridges, there was a land connection between Australia and the Asiatic mainland. This provided an avenue for the dispersal of forms which evolved in and about Australia. Furthermore, this latter land connection accounts for the pre-Miocene distribution of some birds and possibly all mammals which occurred in the Holarctic, Ethiopian, and Oriental regions. Remnants of this land connection are readily discernible even today.

Malaya and West Borneo formed a land mass during Miocene times, while the western Malay archipelago was largely inundated (deBeaufort, 1951). Such disconnections with the formation of islands appears to account for the successful survival of many relict forms which are found in the Australasian region.

On the assumption that Antarctica was the center of origin for the ancestors of present-day birds, and perhaps even for ancestral Metatheria and Eutheria, we may then attribute the occurrence of relict orders in both South America and Australia and the adjacent islands to population emigrations in these two directions along natural avenues of dispersal.

Subsequent isolation resulting from inundation of the lower land areas (deBeaufort, 1951), accompanied by the interruption of direct land connections, may have afforded conditions essential to survival and success of the isolated forms or for their continued evolution resulting in a high degree of specialization.

While South America served as the terminus for forms migrating in that direction, two major avenues for dispersal were open to those forms which migrated to Australia and thence to the Asiatic mainland. The first of these routes lies along the eastern coast of Asia to Alaska and then south along the western part of the North American continent, while the second dispersal route leads westward from Malaya across India and the Middle East to Europe on the one hand, and to Africa and Madagascar on the other hand.

These routes of dispersal appear to coincide with or approximate the marginal limits of the major zoogeographic realms (fig. 1). DeBeaufort (1951) has pointed out that the major land masses have existed since pre-Cambrian time, although there has been change in the topography and climatic conditions. This has likewise been noted by Pauly (1952).

ANATOMICAL INFERENCES

Based upon a study of the carotid artery patterns in several orders of birds (Glenny, 1940–1953 and unpublished papers), and particularly those of the Psittaciformes, there appears to be a high degree of coincidence in the distribution of carotid evolutants and the apparent routes of dispersal as noted above.

The aortic arch system affords only one source of evidence for the evolution of birds, but recent studies on parts of the skeletal system appear to further substantiate the view herein presented. Glenny and Amadon (1954), Glenny and Friedman (1954), and Glenny (195–) have reported on the reduction of the clavicles in several birds, and have found this feature to be independent of other characters, and consistent for the genus.

Classification of Bird Clavicles

Class 1+: furcula complete with hypocleidium; class 1: furcula complete, hypocleidium lacking; class 2: clavicles separate and sword-shaped, interclavicle reduced to a ligamentous bridge (pons); class 3: clavicles greatly reduced, epicleidium bone, corpus claviculi ligamentous, interclavicle ligamentous if present; class 4: clavicles entirely ligamentous, but maintaining an attachment to the clavicular face of the coracoid bone; class 5: clavicles completely absent, clavicular face of the coracoid bone lacking.

In so far as our present knowledge is concerned, among the parrots evolution from a class 1 to class 2 or class 3 clavicle occurs with greater frequency in genera in the Australian realm (9 genera) than elsewhere, and is found in more psittacine genera in the Ethiopian realm (3 genera) than in the Neotropical realm (1 genus). Three genera of the Loriinae and all of the Micropsittinae show evidence of clavicle evolution, none of the Kakatoeinae thus far studied show any reduction of the clavicles, and of the South American Psittacinae the genus *Forpus* alone shows evidence of a considerable reduction of the clavicles.

The Dodo (*Didus cucullatus*) presented a class 2 clavicle, while the Pheasant

Pigeon (*Otidiphaps nobilis*) was found to have a class 3 clavicle. Both of these birds inhabited areas not far from their presumptive center of evolution.

Of the Psittacinae, genera presenting the A-2-s carotid arrangement and some degree of clavicle reduction are *Cyanoramphus*, *Northiella*, *Platycercus*, *Poicephalus*, and to a lesser extend *Psittacus*, while genera presenting the A-1 carotid arrangement and class 3 clavicles are *Melopsittacus*, *Polytelis*, and *Agapornis*.

McDowell (1948) has shown that the classification of birds based on the bony palate results in division of the former Palaeognathae. Furthermore, he appears to present sound evidences of closer affinities between the tinamous and rheas than between the rheas and other "palaeognathous" birds. It should be noted further that in each of McDowell's groups those forms with most similar palatal structure have or had a more nearly similar geographical distribution. The arterial arrangement-pattern and skull structure of the Apterygiformes are of a highly specialized nature (Glenny, 1942; McDowell, 1948).

The A-2-s carotid arrangement can be traced from Australia and New Zealand (*Cyanoramphus*, *Northiella*, *Psephotus*, and *Platycerus*) to New Guinea (*Psittrichas*), Madagascar (*Coracopsis*), and Africa (*Psittacus* and *Poicephalus*). All of the South American parrots have the A-2-s carotid arrangement, and except for *Forpus* the class 1 clavicle.

NEOGEOGRAPHICAL INFERENCES

The Sphenisciformes appear to have inhabited the southern hemisphere since their origin (Simpson, 1946), and these birds are now regarded by Wetmore (1951) to have unknown relationships with the rest of the Neornithes.

McDowell (1948) has emphasized the similarities in the bony palates of both the tinamous and rheas and their dissimilarities to those of the ostrich, emus, and cassowaries. These observations are of interest when considering the geographical distribution of these different birds.

The Gaviiformes and Colymbiformes are highly evolved forms possibly derived from an earlier odontongathous line which had migrated into the northern hemishere. The resultant orders persist in the hemisphere in spite of their small number of species.

The distribution of the kiwis is a very limited one, nor is there evidence that they ever had a wide distribution.

In the Procellariiformes, the largest number of species are found to nest on islands in the southern hemisphere from about 30°S. latitude to about 65°S. latitude.

Due to the wide distribution of the Pelecaniformes, Ciconiiformes, Anseriformes, Falconiformes, Charadriiformes, Cuculiformes, and Strigiformes without any notable features in this distribution, little information is to be gained by a study of their distribution, in so far as the center of their origin and evolution is concerned. It is possible that the ancestral stocks for these orders arose in Antarctica and then spread through the major parts of the world, but at present sufficient evidence is not available to substantiate such a view.

Mayr and Amadon (1951) consider the gallinaceous birds to be of very early origin. Based on present-day distribution and certain anatomical differences, I would presume that the early galline ancestors could have had their origin and early evolution in Antarctica. The subsequent isolation and independent evolution of the Cracidae and Opisthocomidae of South America could account for some of the differences between them and their Old World allies. Likewise, isolation and the subseqent evolution of the Megapodes in the south and southwest Pacific islands could account for important differences between them and the Phasianoidea. The major evolution of the Phasianoidea undoubtedly took place in Asia, with a subsequent distribution throughout the Holarctic region.

Placing the Megapodidae and the Cracidae in the same super-family is somewhat misleading and taxonomically unsound. In the first place these two families do not

have the same carotid formula. The Megapodidae are characteristically unicarotid while the Cracidae are bicarotid (A-1). Any structural similarities between these two families may be due to basic characteristics found throughout the order, and achieving various levels of evolution within the different families.

In the gruiform assemblage, there are many structurally diverse families. This is suggestive of an early origin and subsequent wide divergence of early forms. The Mesoenatidae are relict species which have become quite specialized, probably as a result of their insular isolation (Glenny and Friedmann, 1954). Reduction of the clavicles and reduction or loss of the flight-function characterize the members of this family. The Turnicidae have a rather wide distribution, but the center of evolution of this family may well have been in the region of Australasia since they do not occur in the Neotropical realm. Distribution of the Gruidae indicates two avenues of dispersal from southeast Asia after an earlier evolution in the vicinity of New Guinea and Australia. The Aramidae and Psophiidae may represent the specialized descendents of early gruiform migrants from Antarctica to South America, and an ancestral ralline stock from Antarctica may have given rise to the Rallidae since the distribution of genera and species on the islands of the southern hemisphere would tend to confirm this view. The origin of the Heliornithidae likewise may have been in Antarctica, with dispersal taking place into South America and through Malaya to Africa. *Rhynochetos* is an insular relict derived from the rapidly evolving gruine stock of the Australasian region, while the Eurypygidae and Cariamidae may be relicts of early South American forms. The Otidae ancestors appear to have taken the southern dispersal route from Malaya, across India and the Middle East to Africa and Europe.

Australia and the adjacent islands appear to have been important centers of early evolution of the Columbidae (Glenny and Amadon, 1954) and certainly this region was the center for subsequent evolution of many of the Psittaciformes. The present distribution of parrots can be accounted for on the basis of their origin in and subsequent movement from Antartica to South America and Australia and New Zealand. The occurrence of the Loriinae and the Kakatoeinae in Australia and the islands of the south and southwest Pacific tends to confirm the view that this area formed an important center for psittacine evolution. Considerable evolution of the carotid arteries has taken place in the Australasian parrots whereas there is a seemingly rigid uniformity in the carotids in the Neotropical parrots.

Two centers of early evolution and dispersal are possible in the Caprimulgiformes (Australasian and South American), although a single center in Australasia would be possible if it were followed by a world-wide dispersal.

Whether or not the families of the Apodiformes are closely allied may be a matter in question, but the origin of these birds must have been quite early in the history of the class, and probably occurred in Antartica, since the Apodidae are found in both South America and in the Old World. The Hemiprocnidae are entirely Australasian in their present distribution, while the Trochilidae appear to have had their center of evolution and present distribution in South America and the adjacent land areas.

The trogons, relationships of which are uncertain, are found in southeast Asia and tropical America. Their distribution closely resembles that of the Heliornithidae (deBeaufort, 1951). A doubtful fossil of *Trogon gallicus* is reported from the lower Miocene of France. If this is in fact a specimen of the genus *Trogon*, then these birds had achieved a wide distribution during the Tertiary period, but have survived only in areas where the climate has proved to be more amenable to their success. Their present distribution is suggestive of an origin in Antarctica with subsequent evolution in both South America and in southeast Asia.

Distribution of the Galbulidae, Bucconidae, and Ramphastidae in South America, the Capitondiae in South America, Asia, and Africa, the Indicatoridae in Africa, and the Picidae world-wide is strongly suggestive of an Antarctica origin of

the Coraciiformes followed by the subsequent establishment of centers of evolution in the other zoogeographic realms.

The geographic isolation of the Coliiformes in Africa, without recognizable relationships to any particular order of birds remains a problem. It is possible that these birds represent the evolutants of early passerine African immigrants.

Similarity in the bony palate of the Passeres and the restricted distribution of neotropical and old world families of passerine birds is suggestive of both a common ancestry and an early separation or segregation geographically. The common origin and subsequent geographical isolation of these particular families can be accounted for on the basis of rapid evolution of diverse pro-familiy types in Antarctica, followed by dispersal to the adjacent land areas with or in advance of the advent of an adverse climate or with increases in strongly competitive species and rather large populations.

The influence of an adverse climate on avian and mammalian populations in Europe and in North America is most remarkable when comparing the species of these areas during the Tertiary and the Quaternary periods.

ECOLOGICAL INFERENCES

The process of speciation among forms with a low biotic potential usually takes place at a lower rate than among forms with a high biotic potential. This appears to hold even among populations which sustain a very high annual mortality.

Under conditions of relative isolation, a small homogeneous population may survive and undergo notable evolutionary changes. Innumerable instances of insular isolation can be offered as evidence for this rather general observation. The Kagu, Megapodidae, Mesoenatidae, and many other birds and mammals serve as simple examples of this. In larger land areas, ecological niches serve to accomplish essentially the same results. These more notable evolutionary changes may be structural, color, dietary, or physiological.

Romer (1945) has pointed out that the success of newly evolved forms is dependent upon relatively little pressure from competitive forms, but more particularly on freedom from predation by already well-established forms. Once established, a new group of organisms may survive and evolve quite rapidly in spite of other competitive forms.

An abundance of moisture and a lack of severe fluctuations in temperature—with temperatures always above freezing—are optimal conditions (deBeaufort, 1951), and optimal conditions are essential for the establishment of new and rapidly evolving forms of life.

From available information, we may infer that the climate in Antarctica was favorable for survival of both pro-avian and pro-mammalian forms. In addition, a large flora appears to have developed as evidenced by the large Jurassic coal desposits. During the same period, a large ice sheet covered a large part of Africa (Pauly, 1952). Therefore the origin of birds or mammals in Africa would appear to be out of the question during this period, particularly in as much as rapid evolution does not take place under such conditions.

Presumably competition and pressure from predation was not so severe in Antarctica during the Mesozoic Era, or shall we say that we have no evidence to show that this land mass was inhabited by the giant lizards that are reported from North America and Asia during this period. As a result, we might conclude that generally more favorable conditions existed in Antarctica for the origin and early evolution of both birds and mammals than existed in other parts of the world.

CONCLUSIONS

The occurrence of quasi-avian or quasi-mammalian forms on other and widely separated parts of the world cannot be held in evidence that these widely separated areas served as multiple centers of origin for either birds or mammals. Such a view

would necessitate supplanting the monophyletic origin for a polyphyletic origin of either birds or mammals. This in turn would necessitate the reconstitution of either or both groups and reassignment to their proper components. It is possible that some presumptive "mammals" are in effect quasi-mammalian forms just as *Archaeopteryx* and *Archaeornis* are to be regarded as quasi-avian forms rather than true birds.

The known distribution of the primates can be accounted for in much the same way as that given for the distribution of parrots. Likewise we can account for the wide distribution of marsupials in the same manner. Romer (1945) has pointed out that the marsupials and other small mammals of South America were subjected to much less predation prior to the land connection between North America and South America and attributes the reduction in numbers of species in South America to this factor.

The geographical distribution of the orders of birds and mammals provide us with information from which we may draw inferences with respect to the routes of dispersal of these animals. These dispersal routes appear to coincide with the marginal limits of the major zoogeographic regions.

The occurrence of trogons, swifts, parrots, marsupials, and primates in both South America and Australasia; the occurrence of tinamous, rheas, and trochilids in South America but not Australasia; and the occurrence of kiwis, emus, cassowaries, and monotremes in Australasia but non-existant in South America has yet to be satisfactorily explained on the basis of an origin in Australasia. Their origin in Antartica, however, would make possible a natural dispersal to both Australasia and to South America and thus facilitate the explanation of some of the phenomena of vertebrate distribution. It is within the realm of possibility that the remains of many of the early birds and mammals or their ancestors still lie entombed by the snow and ice which covers the land that is Antarctica.

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A POSTHUMOUS WORK BY JESSE E. HYDE[1]

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The golden age of paleontological description has long since passed. No longer can private individuals afford to publish numerous quarto volumes, illustrated by splendid lithographs, such as those by Joachim Barrande on the Paleozoic of Bohemia. Nor can the geological surveys, wealthy as some of them may be, devote a considerable portion of their budgets to the publication of works describing the fossils of their states. Therefore, when a notable exception to the general rule appears, it should receive more than passing notice. Such is the publication here reviewed, a substantial volume of 355 pages and 54 plates.

It is not to be supposed that the Ohio Division of Geological Survey was allotted special funds (would that it had been!) to issue this major contribution to the paleontology and stratigraphy of the state. It was only by the exercise of considerable ingenuity and the choice of an unusual method of printing, that the Survey was able to undertake such a project on its modest publication budget. The entire book, with the exception of the plates, is reproduced by an offset process that yields remarkably clear letter-press and all the appearance of printing except for alignment of the right-hand margin.

Before appraising the contents of this work, perhaps some account of the reason for its late publication, eighteen years after the author's death, may be in order. Jesse Earl Hyde was a perfectionist who was constantly revising his work to attain greater accuracy and effectiveness in presentation. As early as 1909, he had written much of the text and prepared illustrations to accompany it. There is evidence, in the manuscript and in his correspondence, that he was rewriting portions of it until shortly before his death. He did not think of it as his *magnum opus* but it did have associations going back to his childhood and he was reluctant to write *finis* to his work until he considered it as good as he could make it. Death came before he had attained his goal.

The manuscript had been prepared for the Ohio Survey and after his death it was placed in that institution's hands together with the numerous drawings and plates. The Survey was never a wealthy institution and the cost of issuing such a large work proved to be beyond its means for a long time. It was only when the present director of the Survey acquired the machinery for the offset printing that publication of Hyde's work could be even thought of. In the meantime, some fourteen years had passed and much work had been done on Mississippian invertebrates and on Ohio stratigraphy. Moreover, the manuscript needed considerable editing; in some cases, there were as many as three different versions of a particular section which had to be collated and reduced to one. The Survey was particularly fortunate in having the services of Mildred Fisher Marple for the huge task of editing, proof-reading, and comparing descriptions with the type specimens, when they were still in existence. She has wisely decided to make as few alterations as possible in the work of Hyde and to leave it as much as possible a presentation of Hyde's views when the manuscript left his hands.

The problem which Hyde undertook to solve is far from small. The Mississippian formations of Ohio are deceptively simple in aspect for the beginner; it is only after he attempts to map any one of them that he finds himself

[1] "The Mississippian Formations of Central and Southern Ohio" by Jesse Earl Hyde, edited by Mildred Fisher Marple—Ohio, Division of Geological Survey, Bulletin 51, 355 pp., 54 pls., 1953 ($2.50).

involved in a bewildering array of facies changes which neither lithology nor faunas will unravel with ease for him. In addition, the worker on the Mississippian of Ohio is hampered by the scarcity of well-exposed sections; most of them seldom extend far enough downward or upward to give him a satisfactory datum plane. He must therefore work with as many fragmentary sections as the nature of the terrain will afford and content himself with approximations when a well-exposed section would yield certainty. Hyde did not flinch at the mountain of work which this involved; the selected sections given in his work are but a small proportion of those he measured.

Other difficulties arose from the previous work on the subject. A glance at the "Notes on the Classifications" (p. 7-14) will show how the boundaries of the formations varied from one author to another and what a chaos of conflicting opinions Hyde had to reduce to order.

The paleontology was in no better state. Loose interpretation of the value of species had multiplied names for the same form to an almost ridiculous extent; to make matters worse, many of the supposed species were ill-defined and the material on which they were based had been lost. Hyde created very few new species and varieties, exercising commendable restraint in this respect, and studied intensively those species which had been described. The result was a reduction rather than an increase in the number of Mississippian species in Ohio and critical notes justifying the relegation of rejected species to synonymy.

Hyde's work, both in stratigraphy and in paleontology, forms a basis for further investigations of the Mississippian of Ohio, a sure guide whose absence was sorely missed during the course of many mapping and paleontological projects undertaken by the students of the Department of Geology of the Ohio State University for the Ohio Division of Geological Survey. Their results may amplify those of Hyde but his work remains as the fundamental authority on the subject. Its publication forms a lasting monument to the memory of a great Ohioan and a sound geologist.

Historical Aspects of Organic Evolution. *Philip G. Fothergill.* Philosophical Library, New York. 1953. xvii+427 pp. $6.00.

This book is divided into two parts. The first part deals with the development of the idea of organic evolution, from the ancients to about 1900; the many writers of this period, with their theories and controversies, are discussed in some detail. The second part deals with "the chief modern causal theories of evolution and their relation to formal genetics"; it contains a fairly detailed account of cytogenetics, and a discussion of the causal theories advanced during the first forty years of the twentieth century. The book concludes with an appendix, a comprehensive bibliography, and an index. There is quite a bit of quoted material, and numerous references to the bibliography. The few figures are diagrammatic, illustrating chiefly genetic and cytogenetic phenomena.

The author has presented a very complete and relatively unbiased account of the development of one of the most important biological concepts. The book will be of considerable value to students, teachers, and biologists generally, in that it will help them understand how the evolution concept has developed. It does not adequately present the current concepts of how evolution takes place, as the contributions and developments of the last decade are not mentioned; of the more than 800 entries in the bibliography the latest is 1946, and there are only seven entries later than 1942.

DONALD J. BORROR

FACTORS AFFECTING PRODUCTION AND CLARIFICATION OF DEXTRAN

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Dextran, a glucose polymer, has been known since the nineteenth century. It was sometimes encountered as a slime in large globular masses during the processing of cane and beet sugar, where it increased the viscosity of the sugar solution and retarded filtration and crystalization. When these globular masses were examined microscopically, they were found to be made up largely of chains of encapsulated cells which were later classified by Hucker and Pederson (1930) as belonging to the family *Coccaceae*, tribe *Streptococceae*, genus *Leuconostoc*, species *L. mesenteroides* and *L. dextranicum*. Niven *et al.* (1941) reported that a few strains of *Streptococcus salivarius* and *Streptococcus bovis* are also able to synthesize, from sucrose and raffinose, an insoluble carbohydrate which seems to be a dextran.

Conditions for the preparation of dextran were determined by Tarr and Hibbert (1931), who stated that sucrose was the only suitable carbohydrate substrate for the production of dextran. Many investigators have reported that certain accessory substances are necessary for the growth of *Leuconostoc* (Snell *et al.*, 1938, Bohonos *et al.* 1941, 1942; Gaines and Stahly, 1943; Whiteside-Carlson and Carlson, 1949a and 1949b). The addition of various substances have been shown to increase the yield of dextran (Carruthers and Cooper, 1936; Stacey and Youd, 1938; Bouillene, 1938; Daker and Stacey, 1939, Hassid and Barker, 1940; Stacey, 1942; and Stahly, 1943).

The enzymatic synthesis of dextran has been described by Hehre (1941, 1946 and 1951) and Hehre and Sugg (1942). Rapid formation and high yield of the enzyme were reported by Koepsell and Tsuchiya (1952). Certain cultural factors affecting dextransucrase production were studied by Tsuchiya *et al.* (1952). The yield of dextran produced by *Leuconostoc* from sucrose and the characteristics of dextran vary considerably with different strains.

The present report describes (a) effects of some factors on dextran production, (b) factors affecting enzymatic degradation of dextran through extended incubation, and (c) dextran opalescence and methods of clarification.

Material and methods

Active cultures of *L. mesenteroides* 683 and B-512 and *L. dextranicum* "elai"[1] were used in this study. For the dextran production two comparative media were used having the following composition per liter.

Medium No. 1. Sucrose 150.0 g., Peptone 2.5 g., Yeast extract 2.5 g., K_2HPO_4 5.0 g., NaCl 2.5 g., and a water extract of sugar refining charcoal 2.0 ml.

Medium No. 2. Sucrose 150.0 g., acid hydrolyzed casein 5.0 g., Yeast extract 1.0 g., K_2HPO_4 5.0 g., NaCl 2.0 g., and $MgSO_4$ 0.022 g.

Sterilization was effected by autoclaving at 15 lbs. pressure for 15 min.

Determination of pH. The pH measurements were made using a Fisher Titrimeter.

[1] *L. mesenteroides* 683, was received from Dr. Carl S. Pederson, New York State Agri. Exp. St., Geneva, N. Y. This culture was originally designated *Betacoccus arabinosaceus* No. 6, from the Orla Jensen collection. *L. mesenteroides* B-512 was acquired from Dr. Kenneth Raper, Northern Regional Research Laboratory, Peoria, Ill. *L. dextranicum* "elai" was obtained from the University of California.

Total Acids. A 10 ml. aliquot of fermented culture media was titrated against 0.1 N NaOH with phenolphthalein indicator. The number of millimoles of total acids was calculated from the volume of alkali used.

Precipitation of dextran, drying and viscosity measurements were carried out as reported previously (Hamdy, 1953).

EXPERIMENTAL RESULTS

Some Factors Affecting Dextran Production

Cultures and nutrients. To determine the relative yields of dextran from the three cultures under investigation, in two different media, six Erlenmeyer flasks, each containing 5 l. of media were inoculated with active culture. After incubation for 5 days, the fermented media were clarified and the dextran in each flask was precipitated, dried and weighed, and the percentage yields were calculated. The results recorded in table 1 indicate that the strain as well as the composition of the medium has an effect on the yield and that medium No. 2 is more satisfactory for the production of dextran than medium No. 1.

TABLE 1

Effect of medium and culture of Leuconostoc on the yield of dextran

Cultures	Percentage Yield*	
	Medium No. 1	Medium No. 2
L. mesenteroides 683	68.0	75.0
L. mesenteroides B-512	53.0	68.0
L. dextranicum "elai"	42.0	66.0

*Based on glucose available from sucrose

It was noticed that during the fermentation of *L. mesenteroides* 683, dextran settled to the bottom of the flask in a very viscous layer, which contained some dextran in the form of hard masses or clumps. When the flasks were shaken manually, all the viscous layer, except the clumps, became uniformly dispersed. Upon standing for several hours, the viscous layer reappeared. This property might be of value, especially in large scale production. *L. mesenteroides* B-512 produced a polymer which was much easier to handle, i.e., it was clarified and precipitated more easily than that of 683 and "elai". *L. dextranicum* "elai" produced a type of dextran which was very difficult to clarify and to dissolve in distilled water. These gross differences in properties may be due to the different molecular structures of the polymers produced.

Extent of incubation. The dextran fermentation was followed during prolonged incubation using different strains and the two media. In the previous experiment it was noticed that the fermented liquor of *L. mesenteroides* 683 contained some clumps of dextran. In order to avoid error in sampling during the course of the fermentation, small Erlenmeyer flasks containing media were used so that at various time intervals analyses were carried out using the entire contents of the flasks. Several flasks of each medium were inoculated with strains 683 and B-512, respectively. Analyses were made to study the effect of extended incubation on total acid production, pH, the dextran yield and the viscosity of 6 percent aqueous solution of the dextran formed.

Duplicate experiments were conducted and the average results are plotted in figures 1, 2 and 3, from which the following information was obtained.

(1) A sharp drop in the pH of all the fermented media occurred during the first 40 hr. of incubation, followed by a further slight decrease up to 110 hr. after which a steady value of 3.8 was maintained.

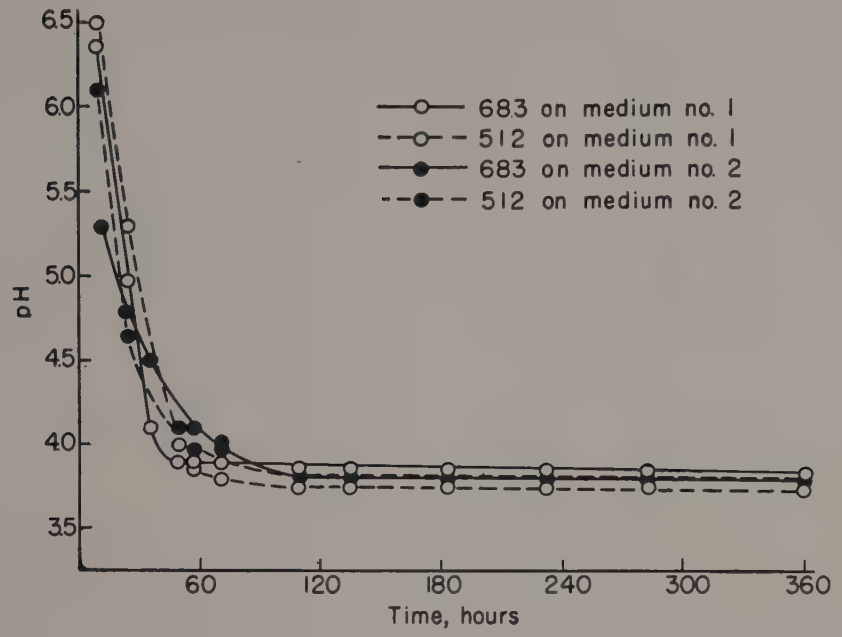

FIGURE 1. Relation between time and pH during the dextran fermentation, using different strains on comparative media.

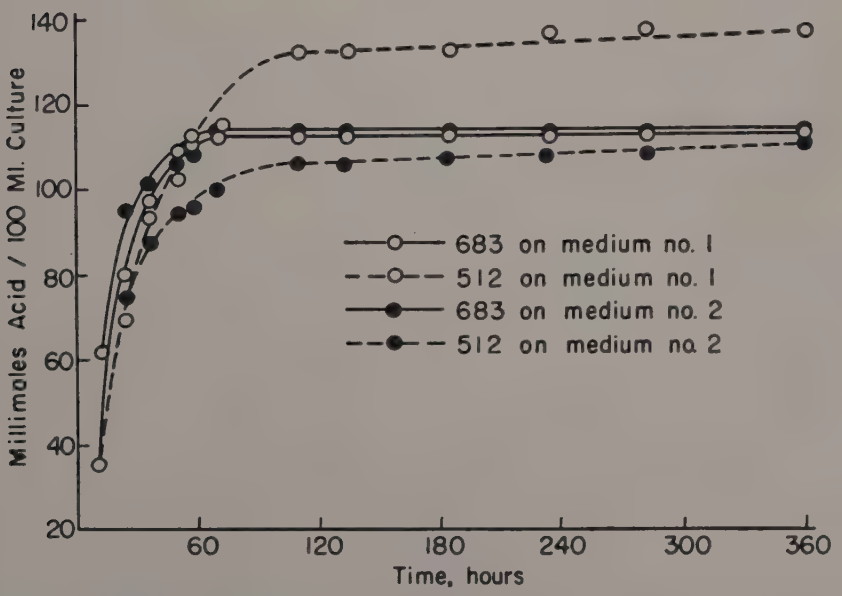

FIGURE 2. Relation between time and total acids in dextran fermentation, using different strains on comparative media.

(2) The amount of total acids increased, following the extended incubation, up to from 72 to 110 hr., after which no significant change was detected.

(3) The relative viscosities of 6 percent aqueous solutions of dextran reached a maximum at approximately 40 hr. after which the viscosities decreased rapidly

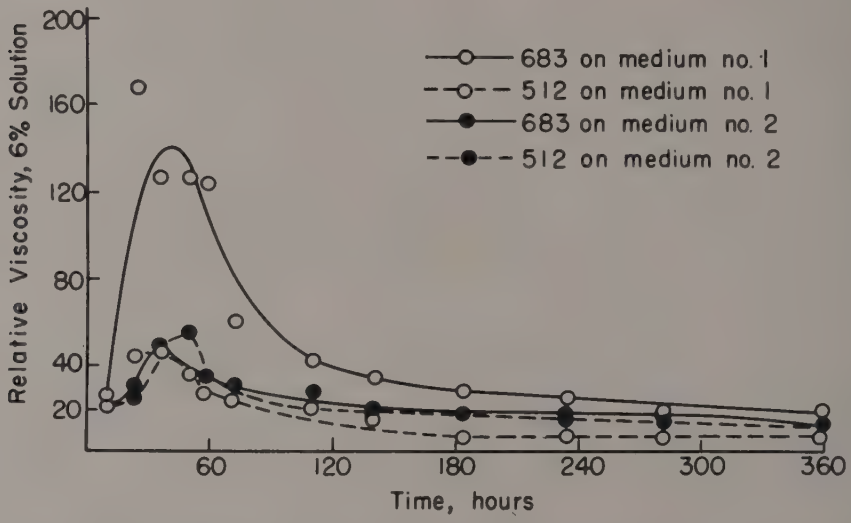

FIGURE 3. Relation between time and relative viscosity of 6 percent aqueous solution of dextran produced by different strains on comparative media.

TABLE 2

Effect of extended incubation on the percentage yield of dextran*

Incubation time (hours)	*L. mesenteroides 683*		*L. mesenteroides B-512*	
	Medium No. 1	Medium No. 2	Medium No. 1	Medium No. 2
12	13.2	23.8	33.3	28.2
24	46.6	32.2	36.6	35.0
36	48.8	68.0	44.4	46.0
49	68.8	65.0	53.2	65.0
58	58.4	64.0	45.0	68.0
72	53.2	60.0	35.0	65.0
110	52.2	59.6	30.0	63.0
135	51.0	58.0	30.0	62.0
185	50.0	56.0	30.0	60.0
234	50.0	55.0	27.0	58.0
282	50.0	52.0	25.4	56.0
360	50.0	50.0	23.2	51.0

*Percentage yield based on the glucose available from sucrose.

but then slowed down after 110 hr. When the variations of pH and of relative viscosity during incubation are compared, it is evident that a decrease in relative viscosity ensued after the pH dropped below 4.0.

(4) The yield of dextran reached a maximum value at 49 hr. incubation time (table 2). In general this was followed by a marked decrease up to 72 hr., after which a less rapid decrease in yield was noted. This may be explained on the basis of degradation of dextran through incubation, which forms low molecular

weight polymer that is not precipitated when 60 percent isopropyl alcohol is added for the precipitation of the dextran.

Mechanical shaking. The two media and *L. mesenteroides* 683 and B-512 were used. The procedure for the preparation of the media, their inoculation and the serial analysis was the same as in the previous experiment except that the flasks were placed in a mechanical agitator (shaker) during the incubation period. The following results were obtained:

(1) A drop in the pH value occurred during the first 53 to 75 hr. after which no further decrease occurred.

(2) There was an increase of total acids up to 53 hr. after which no measurable increase was detected.

(3) There was a slight increase in the relative viscosity of the dextran produced by *L. mesenteroides* 683 followed by a slight decrease.

TABLE 3

Effect of varying concentrations of sucrose, glucose and sodium chloride on dextran production and its viscosity

Flask No.	Percent Concentration			% yield	Relative Viscosity 6%
	sucrose	glucose	sodium chloride		
1	10	—	—	69.2	52.8
2	15	—	—	70.4	48.0
3	20	—	—	65.9	36.9
4	25	—	—	62.4	25.0
5	30	—	—	58.7	18.2
6	35	—	—	64.2	8.1
7	5	5	—	70.2	51.0
8	5	10	—	65.3	48.2
9	5	15	—	48.0	32.4
10	5	20	—	40.0	35.0
11	5	25	—	37.6	34.8
12	5	30	—	32.0	31.4
13	10	—	0.5	54.3	40.2
14	10	—	1.0	37.8	39.8
15	10	—	2.0	32.3	32.2
16	10	—	3.0	21.0	20.7
17	10	—	4.0	18.9	20.3
18	10	—	5.0	15.2	18.9

(4) The yield of dextran by *L. mesenteroides* B-512 was negligible and by strain No. 683 was very poor in both media indicating that mechanical shaking is unfavorable for dextran production.

Periodic neutralization. Two large flasks each containing 10 l. of medium No. 2 were inoculated with *L. mesenteroides* B-512 using 5 percent active inoculum, which had been aseptically neutralized to pH 7.2 prior to its addition to the flasks. The flasks were incubated for 50 hr. and examined every 3 hr. by aseptically withdrawing an aliquot for pH measurements.

Sterile 5 N NaOH was added to one flask only, to readjust the pH to 6.5 while the other flask was left to proceed in normal fermentation. This neutralization was repeated every 3 hr. for the first 24 hr. of incubation.

The dextran was recovered, dried and weighed. This experiment was repeated and the average results are given below:

(1) The relative viscosity attained in the neutralized culture was significantly greater than in the unneutralized culture.

(2) Eighty-five percent of the theoretical yield of dextran was obtained in the neutralized but only 65 percent in the un-neutralized culture.

(3) A 6 percent aqueous solution of the dextran from the neutralized culture had a relative viscosity of 45.0 while that of the untreated culture was 23.0.

Concentrations of sucrose, glucose and sodium chloride. Eighteen 500 ml. Erlenmeyer flasks each containing 250ml. of medium No. 2 were inoculated with *L. mesenteroides B-512* and incubated for 48 hr. at 25°C. Six of these flasks contained the following concentrations of sucrose: 10, 15, 20, 25, 30 and 35 percent. Six flasks contained 5 percent sucrose and glucose in concentrations of 5, 10, 15, 20, 25 and 30 percent. The remaining six flasks each contained 10 percent sucrose plus the following concentrations of NaCl; 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 percent.

Precipitation and recovery of the dextran followed by determinations of yield and relative viscosity of 6 percent aqueous solutions were then made. The results in table 3 indicate:

TABLE 4

The effect of neutralizing and autoclaving the culture medium upon the type of dextran formed, as shown by viscosity measurements of a 6 percent solution

Incubation Time	Relative Viscosity		
Hours	Culture I	Culture II	Culture III
48	46.0*	52.5*	35.0
48	40.2**	38.0**	35.0
72	33.5	35.2	31.5
96	30.0	28.6	27.4
120	29.0	31.8	24.0
144	27.4	31.6	20.5
168	30.0	30.0	17.3
192	29.0	33.0	15.0
216	28.0	31.9	11.0
240	27.0	30.5	10.2
264	26.2	29.0	9.5
288	27.0	29.2	9.0
312	27.2	31.0	8.8

Culture I Neutralized and Autoclaved
Culture II Autoclaved
Culture III Normal Fermentation
*Before Autoclaving
**After Autoclaving

(1) The concentration of sucrose has relatively little effect upon the percentage dextran yield but has a pronounced effect upon the molecular weight of the dextran formed as measured by the viscosity of 6 percent aqueous solutions.

(2) Varying the concentration of glucose and sodium chloride had a marked effect upon the yield of dextran obtained from 10 percent sucrose and a lesser effect on the viscosity of 6 percent solutions; the higher the concentration of these materials, the lower were the yield and the viscosity of the dextran.

Enzymatic Hydrolysis of Dextran

Confirmation of enzymatic mechanism. It has been shown that degradation of dextran can be accomplished through extended incubation of the culture medium (Hamdy, 1953). Jeanes *et al.* (1948) reported that this hydrolysis is due to "autolysis of the *Leuconostoc* cells". The following experiments were conducted to investigate this mechanism and to study some factors affecting the degradation of dextran upon extended incubation of the culture.

Three flasks, each containing 1500 ml. of medium No. 2, were inoculated with *L. mesenteroides* B-512 and incubated for 48 hr. The pH of the fermented cultures was measured and found to be 4.0. One culture was neutralized with 5 N

NaOH and autoclaved for 20 min. at 15 lbs. The second culture was sterilized by autoclaving without prior neutralization. The third culture was allowed to proceed normally. Aliquot portions were taken aseptically from each flask every 24 hr. The dextran was precipitated and its relative viscosity was measured in a 6 percent aqueous solution. The results recorded in table 4 indicate that heat sterilization destroyed the hydrolytic component in the fermented media and that a slight decrease in viscosity, upon extended incubation, was noted in both cultures I and II.

TABLE 5

The effect of removal of bacterial cells by filtration of the culture medium upon the degradation of dextran

Time (hours)	Relative Viscosity	
	Filtered	Unfiltered
48	21.4	20.4
72	21.4	16.5
96	21.0	14.2
120	21.0	8.0
144	20.8	6.5
168	21.3	4.2
192	21.0	3.6

TABLE 6

The effect of temperature on the enzymatic degradation of dextran as determined by viscosity measurements of the culture median

Incubation Time (Hours)	Temperature of Incubation C					
	7	20	30	37	45	50
	Relative Viscosity					
0	23.2	23.6	25.4	24.8	28.8	22.2
24	22.6	15.3	15.8	19.6	25.6	20.0
48	22.0	11.0	11.4	16.1	23.4	19.0
72	20.9	10.0	10.2	16.0	22.5	18.0
96	19.0	8.3	8.5	15.2	20.6	17.5
120	18.0	6.8	8.3	15.0	20.4	15.3
144	17.0	6.6	8.0	14.0	20.0	14.7
168	16.0	6.2	7.7	13.6	19.6	14.4
192	15.4	6.0	7.2	13.0	19.4	14.2
216	15.2	6.0	7.0	11.4	19.4	14.0

A further evidence for enzymatic degradation was demonstrated by an experiment in which two liters of medium No. 2 were inoculated with *L. mesenteroides* B-512 and incubated for 48 hr. after which time the fermented medium was divided into two parts; one part was passed through a Seitz filter while the other was left for continued incubation. The degradation was followed every 24 hr. by viscosity measurements of the culture media. The results in table 5 show that sufficient quantity of the hydrolytic enzyme is not present in the culture filtrate after 48 hr. incubation to produce a detectable degradation of the dextran, and further indicate that the hydrolytic enzymes are probably liberated upon autolysis of the bacterial cells.

When it was found that degradation of dextran through extended incubation was apparently due to enzymes liberated upon autolysis of cells, it was decided to investigate factors affecting this degradation.

Effect of temperature. Six flasks each containing 1500 ml. of medium No. 2, were inoculated with *L. mesenteroides* B-512 and incubated until maximum vis-

cosity had been reached. Then the effect of temperature on degradation was studied by incubating the flasks at 7°, 20°, 30°, 37°, 45°, and 50°C, respectively. Viscosity measurements of the culture medium were conducted at 25°C to follow the depolymerization. The results in table 6 indicate that the most favorable temperature for the enzymatic hydrolysis seems to be in the range of 20° to 30°C.

Effect of sucrose concentration. Five flasks, containing ingredients of medium No. 2, except for sucrose which was added in concentrations of 5, 10, 15, 20 and 30 percent, respectively, were inoculated with *L. mesenteroides* B-512 and incubated for a period of 240 hr., approximately 192 hr. after maximum viscosity

TABLE 7

Effect of sucrose concentration on the molecular size and enzymatic degradation of dextran, as shown by viscosity measurements of 6 percent aqueous solutions of dextran formed by L. mesenteroides B-512

Incubation Time (Hours)	Relative viscosity of 6 percent of dextran produced in the following sucrose concentrations				
	5%	10%	15%	20%	30%
48	68.1	55.7	47.1	32.1	24.0
72	56.2	52.6	41.2	26.0	18.0
96	54.3	48.2	34.5	21.8	12.0
120	44.1	46.5	27.0	12.0	8.4
144	43.9	35.2	22.0	8.4	6.2
168	43.9	34.8	18.0	6.0	5.9
192	42.7	34.3	16.2	6.2	5.7
216	41.8	34.1	15.8	6.0	5.2
240	41.0	32.0	12.0	5.7	4.6

TABLE 8

Effect of strains and species of Leuconostoc on the enzymatic degradation of dextran, as shown by relative viscosity measuremenls of the culture media

Incubation Time (hours)	*Leuconostoc* cultures used		
	B-512	683	elai
48	65.2	306.0	69.6
72	41.9	187.5	69.4
96	21.5	135.0	69.0
120	18.1	113.4	66.0
144	16.8	101.1	66.3
168	14.2	96.7	65.2
192	12.7	94.3	67.8
216	11.3	93.3	66.5
240	10.8	92.0	67.0

had been reached. The enzymatic degradation was followed by viscosity measurements and the results (table 7) show that the sucrose concentration has little effect upon the rate of enzymatic degradation while it has a striking effect on the dextran produced. The greater the sucrose concentration, the smaller is the molecular weight of dextran synthesized and degraded accordingly.

Effect of culture. Two strains of *L. mesenteroides*, B-512 and 683, and *L. dextranicum* "elai" were used. Each culture was inoculated into a one liter flask containing 500 ml. of medium No. 2. After 48 hr. incubation the relative

viscosities of the culture media were determined. Incubation was extended an additional 8 days during which time the degradation was followed by relative viscosity measurements of the culture media. Table 8 indicates that strains B-512 and 683 showed considerable enzyme degrading activity while *L. destranicum* "elai" apparently did not. However, the lack of decrease in relative viscosity observed for *L. dextranicum* "elai" cannot be interpreted as indicating the lack of enzymic degrading activity since fractionation of the recovered dextran revealed that hydrolysis does occur as demonstrated by the recovery of a large fraction of low molecular weight polymer. Further investigation should be made before an explanation may be given for the anomalous viscosity behavior.

Effect of aeration. Two flasks, each containing one liter of medium No. 2. were inoculated with *L. mesenteroides* B-512 and incubated for 24 hr. One flask was then aerated during enzyme degradation using a moderate flow of sterile air while the other was not. Degradation of dextran was followed by viscosity measurements of the culture media. The results (table 9) indicate that aeration has no significant effect on the enzymatic hydrolysis of dextran.

TABLE 9

Effect of aeration on the enzymatic degradation of dextran as shown by the relative viscosity of the culture medium using L. mesenteroides B–512

Incubation Time (hours)	Relative viscosity of culture medium	
	Aerated	Stationary
24	25.6	26.4
48	15.3	16.7
72	11.0	11.5
96	10.0	10.8
120	8.3	8.7
144	6.4	6.8
168	6.0	5.8
192	5.6	5.4

Clarification of Dextran

Dextran may be water-soluble, partially soluble or insoluble depending upon the strain of the organism which produces it. *L. mesenteroides* B-512 and 683 produce water-soluble polymers while *L. dextranicum* "elai" produces a partially soluble dextran.

An aqueous solution of a water-soluble dextran has a faint opalescence which varies greatly from a white cream color to a blue tinge. This opalescence is undesirable for a plasma volume expander. The following experiments were conducted to investigate the cause for this opalescence and to establish a rapid, reliable procedure for the dextran clarification.

Dextran opalescence. Stained smears and hanging drop slides were made from an aqueous solution of unhydrolyzed dextran produced by *L. mesenteroides* 683. Bacterial cells, which were found to be present, were counted and an average value per field was determined. The aqueous solution was centrifuged for several hours, after which a noticeable decrease in the opalescence was detected. The supernatant was decanted and the white residue recovered, from which stained smears and hanging drop slides were made. Bacterial counts were performed from both preparations and an average value per field was determined and the following information was obtained:

(1) The supernatant had a bacterial content considerably lower than the original aqueous solution of dextran.

(2) The residue was found to be mostly bacterial debris with particle diameters in the size range, 0.2 to 0.5 μ. In comparison, the normal cells of *Leuconostoc* cultures have diameters in the range of 0.8 to 1.0 μ.

(3) When these bacterial cells were resuspended in water, a white opacity was noticed comparable to that of the original aqueous solution of dextran. It can be stated that the opalescence was mostly due to the bacterial debris.

Methods of clarification

(A) *Use of super-cell and norit.* Activated charcoal (norit) was added to a 5 percent aqueous solution of crude dextran; the mixture was heated to 80°C and filtered while hot through a pad of super-cell in a Buchner funnel under vacuum. Various thicknesses of the super-cell pad were used to establish the most efficient thickness. Clarification was accomplished, but it was noticed that the super-cell adsorbed a considerable amount of dextran from the solution.

(B) *Clarification during acid hydrolysis.* One hundred twenty-five grams of crude dextran were partially hydrolyzed in 2 l. of 0.1 N HCl at 60°C in a water bath. The hydrolysis was followed by viscosity measurements and was stopped by neutralization when the relative viscosity reached a value of 2.8. The solution was filtered through a Berkefeld filter and the dextran was precipitated. It was noticed that the opacity of the dextran solution was markedly reduced during hydrolysis and completely absent after filtration.

(C) *Filtration of dextran.* Seitz and Berkefeld filters were used to eliminate the bacterial cells from the aqueous solution of 6 percent crude dextran. It was found that a repeated filtration was necessary to clear the dextran solution as some of the bacterial debris passed through the filter.

The fermented culture medium was diluted with distilled water, using 20 percent by volume, and filtered through large Seitz filters (capacity—2 l.). The dextran was precipitated and it was found that an aqueous solution of this dextran was clear. This method proved to be quick and efficient.

DISCUSSION

The production of the high molecular weight polysaccharide dextran, for use as a plasma expander, has been given considerable attention by many investigators. It has been shown in this investigation that there are many factors involved in this fermentation. The selection of the appropriate culture and maintenance of its nutritional requirements; i.e., amino acids, vitamins, and minerals, were found to be highly significant factors. *Leuconostoc mesenteroides* B-512 and medium No. 2, which contained other than sucrose, hydrolyzed casein, yeast extract, potassium monohydrogen phosphate, sodium chloride and magnesium sulfate, gave a high yield of dextran, which was easily clarified and precipitated as a very fine powder. The periodic neutralization early in the fermentation was found to increase the yield of this high molecular weight polymer. This may be explained on the basis of the optimum pH for production and activity of the dextransucrase enzyme.

Koepsell and Tsuchiya (1952) established that the optimum pH for the production of the enzyme dextransucrase by *L. mesenteroides* B-512 ranges from 6.5 to 7.0 in the growing culture and that dextran synthesis, in the presence of the enzyme is optimum at pH 5.0 to 5.2. It seems that periodic neutralization to keep the pH around 6.5 during the initial hours of the dextran fermentation, favors the enzyme production, which, in turn, results in a higher yield of the synthesized dextran, especially when the pH drops to 5.0 to 5.2. In contrast, the regular fermentation, where the pH drops to 6.2 within 6 hr. and then to 3.9 after 24 hr., produces less enzyme, resulting in a decreased activity for dextran production. The higher viscosity of six percent aqueous solutions of dextran

from neutralized as compared with unneutralized fermentations may be due to the more favorable conditions for dextran synthesis in the neutralized media which led logically to higher yields with higher average molecular weight.

The decrease of viscosity of dextran during extended incubation of the culture media, appears to be caused mainly by one or more thermolabile endoenzymes, probably liberated upon the death and autolysis of the *Leuconostoc* cells. The most favorable incubation temperature for this degrading enzyme was found to be in a range of 20° to 30°C. Sucrose concentration, and aeration, seem to have very little effect upon the activity of the degrading enzyme. The molecular weight distribution studies on this enzyme degraded polymer (Hamdy, 1953) revealed a wide range of molecular sizes and a very low yield of the desired molecular weight dextran, indicating the impracticality of using this method commercially.

An interpretation of the dextran opalescence based on the results of this investigation is that the proteins of bacterial cells of *Leuconostoc* which are intimately associated with the polysaccharide and imbedded within the mass of dextran become denatured on the addition of alcohol during the precipitation process and the resulting cell fragments are virtually impossible to remove by supercentrifugation or filtration. A definite relationship existed between the amount of opalescence and the amount of cellular debris. When the fermented medium was first diluted with water to decrease its viscosity and then passed through bacterial filters followed by alcohol precipitation of the dextran, the resulting product in aqueous solution was entirely free of opalescence. No appreciable loss of dextran occurred due to adsorption, as was the case when supercell filtration was used.

SUMMARY

1. Dextran production was found to be markedly affected by various factors, among which were culture used, nutrients available, incubation period, periodic neutralization early in the fermentation, mechanical shaking and sucrose concentration.
2. Medium No. 2, which contained acid hydrolyzed casein, yeast extract, potassium monohydrogen phosphate, magnesium sulfate and sodium chloride, was found to meet the desired nutritional requirements for growth and production of dextran.
3. Mechanical shaking is unfavorable for dextran production.
4. Periodic neutralization of acidity early in the dextran fermentation resulted in higher yields of high molecular weight dextran.
5. Increasing the concentration of sucrose has little effect upon the yield but results in decreasing greatly the molecular weight of the dextran formed, while increasing the concentration of glucose and sodium chloride resulted in decreasing the yield and very little effect on the molecular weight of the dextran.
6. Degradation of dextran through extended incubation was found to be mainly due to an endoenzyme or enzymes liberated upon the death and autolysis of the bacterial cells of *Leuconostoc*.
7. A range of temperatures from 20° to 30°C was found to be most favorable for the activity of the degrading enzyme.
8. Sucrose concentration as well as aeration had little effect on the enzymatic depolymerization.
9. The enzymatic degradation varied with the strain and species of *Leuconostoc*, probably due to the type of dextran formed by the different cultures and its susceptibility to the influence of the degrading enzyme.
10. Dextran opalescence in aqueous solution was found to be due to the bacterial cells and their cellular debris. Elimination of this opalescence was accom-

plished by Seitz or Berkefeld filtration of the fermented culture medium after it had been diluted, if necessary, with distilled water to decrease its viscosity.

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REINTERPRETATION AND THE MECHANISMS OF CULTURE CHANGE[1]

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For the past twenty years or more, acculturation studies have been taking an ever more prominent place in anthropological field research, and understandably so. The more we turn toward the contemporary condition of primitives and others, the more we find ourselves involved in a discussion of the contact situation, its effects and its consequences. However, although we have a great deal of data available concerning the results of acculturation, as Hallowell (1952) has pointed out, we still know very little indeed about the complex mechanisms involved in the formation of a new cultural amalgam. Nor is concern with such mechanisms merely a matter of academic interest, since application of anthropological principles to practical problems rests heavily on an understanding of the processes involved precisely in situations of contact, whatever their specific nature may be.

Various psychological tools have been applied to the problems of acculturation. Hallowell (1945) and Gillin (1945) have, each in a different way, attempted to utilize concepts of learning theory, speaking of rewards and incentives implied in the acceptance of a new item of culture. Recently, Barnett (1952) has approached acculturation under the larger heading of innovation, with the help of Gestalt principles of perception. In terms of learning theory, then, we may assume with Hallowell (1945), that no learning takes place when there are no incentives for learning, that no borrowing takes place when there are no incentives for such borrowing. In other words, culture contact in and of itself is not sufficient to account for the transfer of cultural materials from one group to another. Futhermore, the incentives for the learning of the new cultural materials must already exist among the potential borrowers. That is to say, the items to be borrowed must satisfy the people's own culturally acquired drives. In order for an item of culture to be borrowed, it must have potential meaning for those who would adopt it. However, we may push the matter a step further and ask what happens to the material once it is borrowed. What occurs in the interaction between a functioning culture and a borrowed item introduced into it?

In order to pursue these questions, we would like to add here a social-psychological dimension to the concepts *retention*, *reinterpretation* and *syncretism*. These concepts have been used by Herskovits (1945,1948) in the analysis of Afro-american materials. These concepts, we feel, carry an implict social-psychological dimension which is to be developed, although Herskovits himself handles them exclusively on the phenomenological level.

When, as a result of contact, a new cultural amalgam develops, some material may be carried over unchanged from the period prior to contact. The term *retention* refers to such a maintenance of a feature of the old culture in a changed context: an object, a belief, a behavior pattern. In order to be able to identify such retentions, however, we must have knowledge of the culture in question at a period prior to contact. In other words, we must be able to establish what Hallowell (1946, 1952) has called a "baseline" of cultural change, and it is in the establishing

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of such a baseline, that ethnohistory makes its most important contribution to the student of acculturation.

Retentions may be maintained in various forms: either unchanged, or with certain internal modification. In Haiti today, for instance, quite a few retentions of West African cultural materials may be found: in the way women carry loads on their heads, in the preparation of certain foods and their names (e.g., the dish called *akasâ*). As to the modified retentions, they present a somewhat different category, one of the group of phenomena termed *reinterpretations*.

Reinterpretations may be defined as the retaining, or adopting, of an element from one culture into another, with change of function, meaning, use and even partial form. We may distinguish between two types of reinterpretation. On the one hand, there are those cases, where retentions from a previous period are modified in some way for greater coherence with changed patterns. The making of birch bark objects by the Ojibwa Indians of Wisconsin, for the tourist trade,would be an example of this. On the other hand, we find the somewhat more complex case of those reinterperations which are based on material borrowed from a foreign culture. Here we would do well to keep in mind Sapir's discussion of the conditions under which cultural "lending" takes place. One such condition, says Sapir, is:

> . . . that the culture element in question be capable of detachment from its context and comprehensible as such. There is no doubt that different cultural elements are thus detachable or, what amounts to the same thing, capable of conscious formulation by the native in quite different degrees. We have here a continuous gamut, ranging from the zero, or almost such, of a vocalic or consonantic change to indicate some subtle grammatical notion up to the maximum of what we may awkwardly term "conceptual detachability" of a type of implement of clearcut form, material, and use. Obviously, culture elements are transmissible, roughly speaking, with an ease that is proportionate to their "conceptual detachability." Thus, we expect a ceremonial dance as such to be much more readily transmitted than any notions there may be as to its function; a myth plot more readily than, let us say, the cosmogonic ideas which serve as its frame; an element of decorative design than the precise mechanical technique in which it is executed or its style of artistic treatment in a particular tribe; a definite social custom, say the mother-in-law taboo, than the exact range of meaning covered by a relationship term. (Sapir, 1949, p. 415)

Lack of "conceptual detachability" may thus be seen to function as one possible barrier to cross-cultural interchanges, while cultural lending may be said to be facilitated by such "detachability." However, for actual borrowing to take place, there must also be a potential meaning present for the borrowers in the element in question. That is to say, two groups independently meeting the same detachable element in a contact situation, might make a different choice in borrowing, depending on the resonance awakend in terms of their own cultural background. The fact that West Africans proved able workers in the sugar fields of the West Indies, where the local Indian groups had not, might be cited as a case in point.

Given conceptual detachability, and the imputation of significance to a given cultural element by a group in the contact situation, what happens to the elements borrowed? As we have mentioned, one of the things that may happen is the phenomenon termed "reinterpretation." That is to say, a conceptually detachable element may be modified in some way in order to be incorporated into the way of life of the borrowing group. It is this phenomenon that we wish to examine in greater detail.

Barnett (1942) has shown that in culture change—and acculturation is only a subform of such change-function, meaning, use and form of a given element need not all change at once. It is precisely the independence of these aspects which makes it possible for continuity to exist in change. Now the notion of "continuity in change" may present a problem if we consider it from the point of view of the two cultures that are, presumably, involved in the contact situation. However, if we cease to think of cultures as reified entities, but rather think of human

beings enculturated to one way of life or another, the complexion of the problem changes altogether. At its roots, reinterpretation appears to be a psychological process, and must therefore be attacked on that level, as well as on that of ethnography.

Let us consider an individual reared in a given culture. Unless we assume certain innate, or biologically derived attitudes, we must admit that his attitudes and orientations spring from his own past experience. This itself is largely culturally determined, since no individual may be said to live in a world of "naked" realities, but rather in a culturally constituted universe, something that permits us even to go so far as to say that people in different cultures do not live in quite the same world, do not experience the same "realities." Seen from this perspective, we shall find it not only natural, but indeed quite unavoidable that, faced with previously unknown situations, the individual will attempt to deal with them in terms of what he knows, in terms of the past, thus in terms of his own culture. Indeed, it could not be otherwise, since no "reality" can be experienced without being culturally interpeted. Thus, each culture represents a total "behavioral" world" (Hallowell, 1942, pp.1-8), a perceptual organization of the universe.

It may seem that cases of reinterpretation are numerous and easy at hand. The transplanted African interpeted the teachings of Christianity in terms of his own African view of the world. Similarly, the Europeans when faced with African modes of behavior, interpeted them in the only way they knew how, their own way. For although, as we have seen above, culture molds reality for us, this is not a fact readily grasped, especially by the participant. It is in no way evident to him that he is not dealing with actuality (with that which *is*), instead of seeing that he is dealing with that which is as interpreted for him by his own particular experience, and the experience of his group; in a word, by his enculturation. Thus Père Labat (1724, vol. 1, p.458), describing cases of African spirit possession which he witnessed in Martinique, tells us that these people are so obsessed and so horrified by the devil, that when the devil appears to them they fall into convulsions as though they were epileptics. Similarly, Father Le Jeune (as quoted in Hallowell, 1942, p. 82) thought Ojibwa conjurers to have contact with the devil. In contemporary Haiti, Protestant converts hold that people who smoke will become *zombies*.

If we wish to account for these examples, we must think in terms of the individual's encultruation to a given way of life. The only hypothesis possible for us, then, will be one phrased in terms of the interpretation of new phenomena in the framework of one's pre-existing patterns. Enculturation to a given way of life provides the individual only with those choices or alternatives available within it, or within that of its subdivision, in which the given individual is reared. It does not include the great range of possible solutions to a given problem which would be present, were the solutions *of all* cultures to be considered. Such a possibility is indeed nonsense. In many instances the alternatives would be mutually exclusive, either because contradictory or because inconceivable. Each culture may be seen as a particular mode of adjustment, providing a limited range of alternatives, or problem solution. In a culture where children are carried on the mother's hip, carrying them on the back, tied in a cloth, may be excluded as a possibility. Alternatives outside the context of a particular culture will not be understood by those who live in terms of it. It is this limitation of alternatives, this basic cultural provincialism, which makes it at all possible for people to function. Without it, culture could not exist, children could not be trained, personalties could not develop. There would be no certainity of what to expect, no ability to anticipate reactions, no possibility of predicating the behavior of others. All situations would require detailed investigations, and no routine choices could be made. Only in extreme neuroses do we find anything even remotely approaching such a situation.

Let us return however, to the problem at hand and to the instances of re-

interpretation cited above. The first two, those of Père Labat and Father Le Jeune represent pseudo—rather than actual reinterpretations. They are more nearly cases of what we might call "cross–cultural misinterpretation." The Protestant belief in *zombies*, however, and the identification of African gods with the saints of the Catholic Church, on the other hand, are closer to the concept we have in mind. Perhaps even better examples are the use of a bell and of the sign of the cross in Haitian *vodun* worship, or the use of a printed prayer, sold in the Port-au- Prince market place, as an amulet, worn on a string around the neck. We must, then, distinguish between two phenomena that are functionally quite different: the misunderstanding of the behavior of persons of foreign cultures in terms of the known on the part of individuals whose own background is quite different, and reinterpretation as such. The first case leads to an unwarranted idiosyncratic view, which is in no ways meaningful to the actual actors in the situation. Thus, Père Labat and Father Le Jeune are passive observers in a situation where individuals of other cultures are the actors. On the other hand, for true reinterpretation to take place, it must be patterned and become a part of a culture which results from a contact of two or more different ways of life, and which in turn is different from any previously existing. The reinterpretation might be something which involves the active participation of the group, such as the use of certain objects in a novel way. This is exemplified by the French water faucets used as sword handles in Madagascar, as cited by Linton, or the European use of Chinese explosives for purposes of warfare. It is also exemplified in the previously cited illustrations of the *vodun* use of the bell, the sign of the cross and the printed prayer. However, reinterpretation may also be a matter of folk–enthnology: that is, more or less standardized interpretations of the behavior of another group in terms of one's own belief and attitudes—a culturally patterned form of projection. An example might be cited from Haiti, where some informants were firmly convinced of the widespread existence of *vodun* abroad, citing among other reasons for such belief the fact that many upper class persons had gone abroad to be cured and had returned to visit Haitian *hungans*, priests of the *vodun* cult.

As suggested above, phenomena of reinterpretation are to be divided into two subcategories. On the one hand, we find those which derive their content from the old culture, i.e., modified retentions. With reference to Haiti, this means elements derived from the African past of the population. Secondly, we find those reinterpretations which derive from the culture (or cultures) with which contact is established. The example of the Haitian Protestants seems to include both these facets. Here the older Haitian belief in *zombies*, present at the time when Protestantism was introduced, is reinterpreted to fit the Protestant concept of punishment after death. On the other hand, the Protestant taboo on smoking is reinterpreted to fit the Haitian belief in *zombies*, which has persisted in the context of a changed pattern.

Here we have a case of two-way reinterpretation. This is in many ways similar to the process of *syncretism*. That term, however, has been reserved for a special type of two–way reinterpretation, one in which the two or more elements fuse. Thus in the example just cited, the two elements—one from Haitian belief, the other from Protestantism—are tied together to make one argument. In the more typical case of syncretism, an individual, for instance, might be known by two names—or more characteristically, the identity of two supernatural beings, derived from two cultural contexts, might be mingled. This is true of Catholic saints and African gods in most of the Catholic Afroamerican area (cf. *e. g.* Herskovits, 1937). Similarly, in the development of Christianity in Europe, Christian and pre–Christian elements fused. Pilgrimages in Yucatan may be traced to both Maya and Catholic European sources. Examples of this phenomenon, derived from various acculturative situations and various parts of the world, and a variety of time periods, may be easily multiplied.

The process of retention, syncretism, and reinterpretation as a matter of fact, seem to be universal in the dynamics of acculturation. In so far as diffusion studies, on the basis of distribution maps and archaeological reconstructions, attempt to get at the results of contacts that have taken place in the past and which we cannot fully document, to that extent these social–psychological concepts are relevant there too. Sapir, after all, spoke of the conditions of cultural lending and cultural borrowing with reference not to ongoing contact situations and processes of acculturation. Rather, he was concerned with reconstruction of past events on the basis of contemporary psychological and cultural phenomena, which may be projected backwards in time. Thus the concepts discussed here are thought to be useful not only for the student of acculturation, but to those concerned with culture change in general.

In speaking of the mechansims of retention, reinterpretation, and syncretism, we may perhaps go even so far as to say that only in so far as these mechansisms do occur in a given situation, can we speak of acculturation. As Hallowell (1945), has pointed out although contact is a necessary precondition for acculturation, this fact alone is not sufficient, in the absence of other factors, to produce cultural interchange. A number of studies have shown that culture contact may occur, may indeed lead to specific symbiotic relationships, without resulting in acculturation. One of the factors in such a situation may of course be that of the prevailing power relationships; where one group is obviously dominant, the policy of that group may be a further factor to be considered. Nonetheless, these rather striking features do not alone determine the outcome of the contact situation. Where barriers to acculturation exist, the processes of reinterpretation and syncretism may be impossible and one of two outcome may be brought about. Either retentions will occur in an unchanged context and acculturation, *ex hypothesi*, will not take place. Or, as has been the case with some of the Eastern American Indian tribes, there may be an apparent loss of interest in the old culture and what appears to be total adoption of white ways. This is the case among the Ojibwa Indians of Wisconsin. Here is a group that appears completely acculturated. As Hallowell (1952), has shown however in psychological terms these people are much more similar to the less acculturated Ojibwa Indians of Canada than was to be anticipated from observation of overt cultural features alone. Thus, apparent total cultural abdication may, in psychological terms, not be very far removed from total imperviousness to any external contributions.

This would indicate a serious caution against concluding on the dynamics of acculturation merely on the basis of an inventory of cultural content, without taking into consideration the effect of a changing culture on the personality integration of those who live in terms of that culture.

While admittedly fragmentary, it is hoped that the present analysis may be applicable to part processes of culture change in general, not only to acculturation, since in a sense it becomes irrelevant whether changes are introduced from without, by contact, or from within, by invention and discovery, or indeed by spread from one class to another. (cf., Wolf, 1953). The primary value, then, of the concepts of retention, reinterpretation, and syncretism may be that they permit us some further insight into actual mechanisms of change, and thus give us a greater understanding of the apparent paradox of cultural stability and cultural dynamics.

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Caves of Pennsylvania. *Ralph W. Stone, et al.* Bulletin 15 of The National Speleological Society, Trenton 8, N. J. 1954. 143 pp. $3.00.

This is the most complete state cave survey ever published.

The Bulletin contains the following articles: Geology of Pennsylvania Caves by Wm. E. Davies, Bone Caves by John D. Parker, Animals That Live In Caves by Charles E. Mohr, Cave Insects by S. W. Frost, History and Legend by Henry W. Shoemaker, Kooken—Pennsylvania's Toughest Cave by William Devitt III, Deluge Underground by Donald R. Griffin, Limestone Mines by R. W. Stone, Commercial Caves by R. W. Stone, and Descriptions of Pennsylvania Caves by R. W. Stone.

Several caves in which bone deposits have been found have yielded 33 new species of Pleistocene animals. The material is deposited in the United States National Museum and the Academy of Natural Sciences at Philadelphia.

Fifteen species of vertebrates and 126 species of invertebrates have been recorded from these caves. However, few of these animals are exclusive cave dwellers with any degree of specialization. Included in the volume are some excellent photographs of cave inhabitants and formations.

This report will be of great value to future workers as well as being interesting reading for the layman. It is to be hoped that Ohio may complete a similar project in the near future.

ROBERT E. WOODRUFF

British Caving. An Introduction to Speleology. *C. H. D. Cullingford*, Editor. Routledge and Kegan Paul, Ltd., London. First edition, 1953. xvi+468 pp. $5.50.

British Caving, compiled by the Cave Research Group of Great Britain, is a comprehensive, authoritative guide to British caves, and, at the same time, an outstanding contribution to speleology. The book is divided into two parts. The first section is a scientific survey of British caves. Geology, cave physics, fauna and flora, archaeology, and paleontology are carefully treated. Cave dwelling bats and surface detection of caves receive special attention. The second part deals with the technique of caving. Methods of exploration, cave diving, photography, and surveying are discussed. The chapters on equipment and rigging are accompanied by excellent diagrams, and the entire book is well illustrated by maps and photographs. Also, the methods of the British Cave Rescue Clubs are outlined. An extensive bibliography follows each chapter. The geologist, hydrologist, and biologist will find this book a valuable reference. The explorer will regard it an important guidebook of caving technique.

PHILIP M. SMITH

SOME EFFECTS OF HYPOPHYSECTOMY ON THE DOMESTIC HEN (*GALLUS DOMESTICUS*)

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This study is an attempt to explain some of the effects of hypophysectomy on the domestic hen, with the hope that it will contribute to the general knowledge of hormone deficiency in birds. The effects produced by the removal of the anterior pituitary gland from common laboratory mammals and amphibians are well understood. This is not the case, however, with birds. Consequently, satisfactory phylogenetic comparison between the amphibians, birds and mammamls is not possible. There is almost complete agreement that the deficiency of anterior pituitary hormones in birds causes regressive changes of secondary sex characteristics and of certain endocrine glands, notably the gonads, thyroids and adrenals.

MATERIALS AND METHODS

The animals used in this study, White Leghorn pullets, were hatched from the same brood in December, 1951 and acquired from the Ohio State University poultry farm in June, 1952. The selection of this animal is recommended because of its extensive use in experimental work, its ease of maintainence and handling and its high resistance to bacterial infection when surgically treated.

From a lot of twenty-four pullets three groups of five each were randomly selected and designated as: Group I, normal controls; Group II, hypophysectomized; and Group III, operated controls. The normal control animals were subjected to no experimental treatment, but were maintained under the same environmental conditions as the other animals. The anterior pituitaries of the hypophysectomized pullets were removed by the method described by Rothchild (1948). The operated control birds were subjected to the same treatment as the hypophysectomized pullets except that when the pituitary glands were exposed no attempt was made to remove them. Since Nalbandov and Card (1934) found that the hypoglycemia can be minimized in hypophysectomized hens by reducing the intervals between feedings, an additional hour of light was provided from 1:00 A.M. to 2:00 A.M.

Immediately after the death of a pullet the body was opened mid ventrally and the thyroids and ovaries were removed. These organs were weighed immediately and then fixed in Bouin's. The viscera were inspected for evidence of disease; there was no evidence in any of the pullets used in this study.

In order to determine the completeness of the operation the areas of the pituitaries in the sella turcica were dissected out, fixed in Bouin's, decalcified in dilute nitric acid and imbedded and sectioned in paraffin, as were the thyroids and ovaries. The ten micron sections were stained in azocarmine G-dioxane and counter-stained in orange G-aniline blue. Details are given by Guyer (1936).

RESULTS

Differences in behavior and appearance between the normal control and operated control birds were not observed after the latter had recovered from the effects of the surgical treatment. For several hours following the sham hypophysectomies these birds stood quietly and made little attempt to eat or drink. By the next day, however, these birds were alert and had regained a typical posture with head and tail feathers erect.

With the advent of sexual maturity the combs and wattles of these pullets increased in size and assumed a red, fleshy appearance. They laid eggs in regular cycles which varied with the individuals.

The weights of the thyroids of the two control groups compared closely and statistical analysis indicates that there is no significant difference between the means of these groups. The size and weight of each member of a pair of thyroids usually varied slightly. Microscopical examination did not indicate any notable

TABLE 1

Weight of thyroid glands in grams.

Group I Normal Control		Group II Hypophysectomized		Group III Operated Control	
1	0.300	6	0.164	11	0.296
2	0.318	7	0.170	12	0.364
3	0.280	8	0.050	13	0.296
4	0.248	9	0.146	14	0.242
5	0.232	10	0.318	15	0.322
means	0.276		0.169		0.307

Analysis of Variance

Source	df	mean squares	F
Between means.....	2	0.339	37.70
Within means.....	12	0.009	

Minimal significant difference between means 0.130

difference in the structural and apparent functional state of the glands from the same individual. No marked differences were observed in the thyroids from all the control animals (table 1).

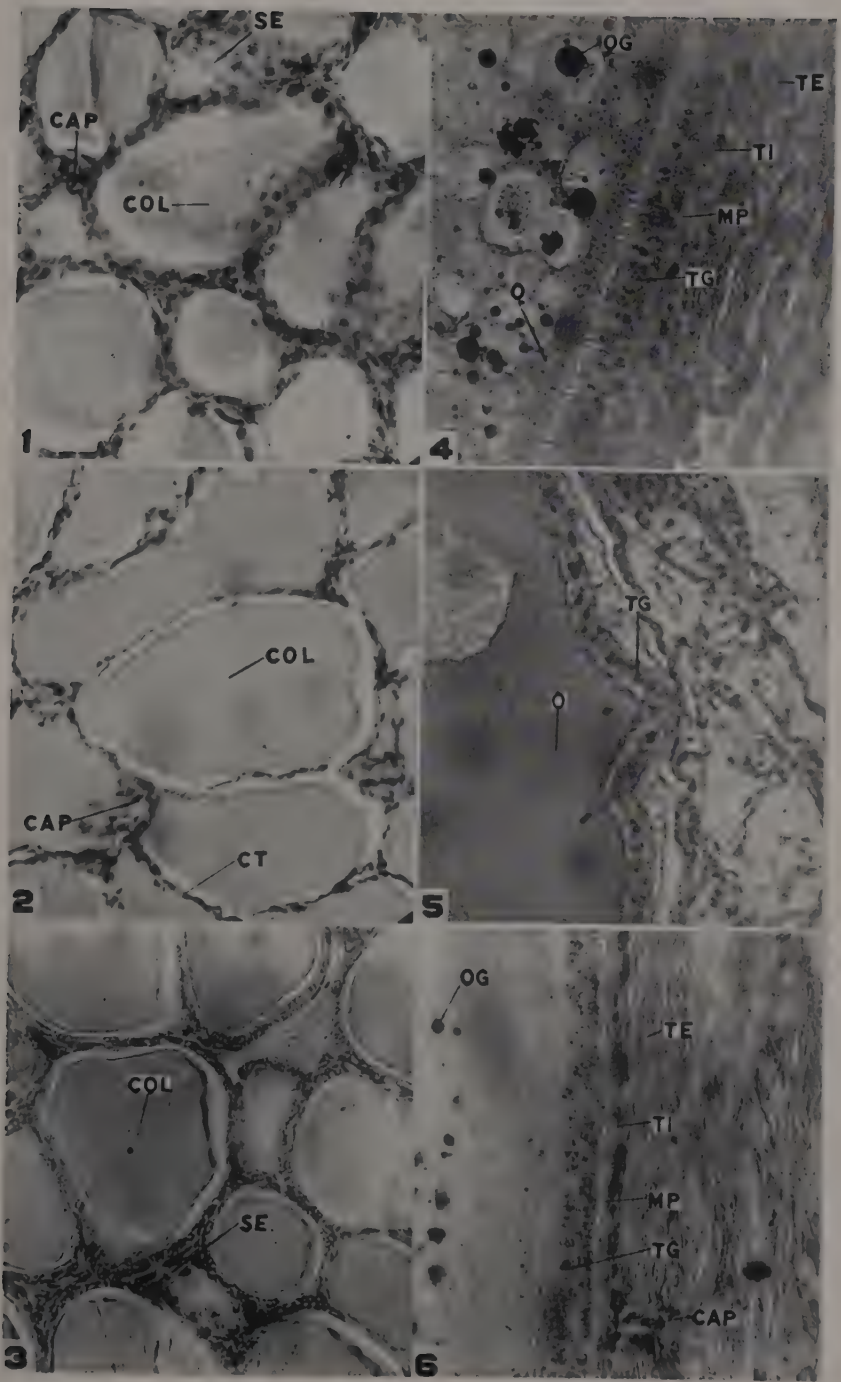
The comparative size of the vesicles in the glands was estimated by counting the number in the microscopic field under 660 × magnifications. Counts were made from several sections from each member of a pair of glands. The average number of vesicles for the operated controls and the normal controls was sixteen. The condition of the secretory epithelium of the vesicles of normal control and operated control thyroids was subjectively compared and did not appear to differ. Figures 1 and 3 show the structure of these glands. The thickness or height of

EXPLANATION OF FIGURES

1. Section through the thyroid gland of a normal control showing the condition of the secretory epithelium and colloids.
2. Section through the thyroid of an hypophysectomized pullet showing the loss of secretory epithelium and increased size of vesicles. There has been shrinkage of the colloid margins.
3. Section through the thyroid of an operated control pullet showing the condition of the secretory epithelium and colloids.
4. Section through an ovarian follicle of a normal control pullet showing the detailed structure of the öocyte and the thecal layers.
5. Section through the ovarian follicle of an hypophysectomized pullet showing the lack of integrated structure of the öocyte and thecal layers.
6. Section through an ovarian follicle of an operated control pullet showing the detailed structure of the öocyte and the thecal layers.

ABBREVIATIONS USED IN FIGURES

CAP.	Capillary	OG.	Oil globule
COL.	Colloid of thyroid gland	SE.	Secretory epithelium
CT.	Connective tissue	TE.	Theca externica
MP.	Membrana propria	TG.	Theca granulosa
O.	Oocyte	TI.	Theca internica


SE
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CAP
6

the epithelium was considered to be medium on the basis of descriptions by Hopkins (1935) and Turner (1948). In tangential sections of vesicles secretory cells were numerous. Although an extensive vascular network was present throughout the glands, the number of blood cells in the capillaries surrounding the follicles was not great.

Upon postmortem inspection of the two control groups the ovaries were large, irregular masses of soft, pink tissue which contained many ova of sizes from a few millimeters in diameter to 25 mm. The larger ova were bright yellow in contrast to the smaller, pale yellow ova which were still imbedded in the cortex of the ovary. The wet weight of the ovaries are given in table 2.

When sections from these ovaries were examined no differences in structure of the tissues of the two control groups were observed. As a criterion for comparison the condition of the follicular tissue surrounding the öocytes was studied. A ring of follicular cells, the theca granulosa, was observed in contact with the developing öocyte. This ring is a single layer of cuboidal cells which are active in the forma-

TABLE 2

Weight of ovaries in grams

Group I Normal Control		Group II Hypophysectomized		Group III Operated Control	
1	19.17	6	1.75	11	18.70
2	45.65	7	1.70	12	15.65
3	20.10	8	0.80	13	28.48
4	45.45	9	1.58	14	4.42
5	23.48	10	7.40	15	22.63
means	30.77		2.65		17.97

Analysis of Variance

Source	df	mean squares	F
Between means.....	2	991.37	10.93
Within means.....	12	90.72	

Minimal significant difference between means 13.13

tion of deutoplasm within the öocyte. The peripheral surface of these cells is smooth and is covered by a basement membrance, the membrana propria, which has a selective function in the supply of nutritive materials to the öocytes (Romanoff and Romanoff, 1949). Two reticular layers invest the structures described above. These are the theca internica and the theca externica. The theca internica is a highly vascular layer about three cells thick. The theca externica is composed of concentric layers of spindle-shaped cells and thick fibers. These relationships are shown in figures 4 and 6.

The appearance of the pituitaryless pullets immediately after the operation was similar to that described above for the operated controls. However, they did not recover as rapidly nor as completely in the next few days. In the first postoperative week the changes in the behavior and the appearance of these birds were not pronounced, but they were slightly less active and appeared to consume less food. No ovulations occured in any of the experimental birds after the anterior pituitary had been removed.

By the end of the second postoperative week the feathers of the hypophysectomized pullets began to take on an ivory cast and no longer lay smoothly along the body. The combs and wattles of these birds also regressed to low, pale ridges of hard tissue. There was some evidence of moulting, but this was not great.

As the length of time increased the effects ascribed to anterior pituitary deficiency became more obvious. Activity was rarely observed and water and food

consumption was much less. In the week preceeding the death of two of the pituitaryless pullets extremely moribund characteristics were observed. The birds stood quietly in a semi-squatting position with the neck flexed and the head slightly drooping. The eyes were usually closed and the tail feathers dragged on the bottom of the cage. One of these died in slight convulsion. Of the three remaining experimental birds, two died later without signs of the extreme conditions described above. The average length of postoperative life for these four birds was 46 days. The fifth experimental pullet exhibited many of the previously discussed changes for part of its postoperative life, but the character of these changes reversed after about five weeks. Gradual increases in activity, food consumption and comb and wattle size over a period of two weeks indicated that ablation of its pituitary had not been complete. Later evidence showed this assumption to be correct. This bird was killed along with those of the two control groups after the fourth experimental bird had died.

The thyroid glands of the hypophysectomized pullets were smaller than those of the controls and more difficult to locate. As seen in table 1, the weights of these thyroids were considerably less than those of either control group. This difference is supported by statistical analysis.

Microscopic examination of these thyroids showed a uniformly different condition from that observed in the normal thyroid. The most striking difference was the nearly complete disappearance of follicular epithelium. Large areas of the sections were studied before observing follicles which were lined with a low layer of these cells. Their nuclei were smaller than those seen in the secretory cells of the normal thyroids. In tangential cuts through the vesicles of these glands secretory cells were not seen. Counts were made of the number of vesicles seen in the field under 660 × magnifications and averaged ten. This index of size was used to compare with normal thyroids and showed that in addition to loss of epithelial tissue the colloids of these thyroids were larger, since fewer of them were seen in an equal area. The interstitial tissue which separates the follicles was greatly reduced and the capillaries imbedded in this tissue were more conspicious. The number of corpuscles in them appeared to be much greater than in normal thyroids. These relationships are shown in figures 1, 2 and 3.

The ovaries of the hypophysectomized birds were greatly reduced in size and contained no ova larger than 3 mm. These were imbedded in the dark red cortex of the ovary. Statistical analysis indicates that the mean weights of these ovaries differ significantly from the mean ovarian weights of the controls (table 2).

Microscopic observation showed that the follicles of these ovaries were not organized into the distinct regions as were the ovaries of the control animals. The theca granulosa was much lower and the nuclei were smaller. This ring of cells still adhered to the öocyte, but in most cases it and the basement membrane had broken away from the theca internica. This latter structure was not clearly distinguishable, but there seemed to be more blood cells in the capillaries of this area of the ovary of hypophysectomized birds than in the corresponding area of the ovary of control birds. There was little indication of concentric layers in the theca externica. The spindle-shaped cells were nearly absent and the recticular nature observed in the control ovaries was not observed. Within the öocyte there was no evidence of oil globules and the yolk platlets, which were seen in a few cases, were irregular masses. These conditions are shown in figures 4, 5 and 6.

No anterior pituitary tissue was seen in the sections from the four experimental birds which died. As was anticipated the anterior pituitary of bird number 10 was not completely excised; about two-thirds of this gland remained.

DISCUSSION

Not all of the changes which result from deficiency of anterior pituitary hormones in the domestic hen are understood, but the results of this study and

studies of others indicate that many of them can be attributed to the elimination or drastic reduction of functions which are regulated directly by these hormones or indirectly by their influence on other endocrine secretions.

The decrease in the size of the thyroids of hypophysectomized pullets and the loss or flattening of the secretory epithelium of their follicles was assumed to indicate that secretion of thyroid hormone from them was greatly reduced or lacking. Hartman (1946) says that the relative sizes of endocrine glands are an indication of their ability to produce hormones. Turner (1948) cites work which shows that the thickness of the secretory epithelium is indicative of the activity of the thyroid gland. Further, an indication of decreased thyroid secretion is the enlargement of colloids in conjunction with the reduction of epithelium. According to Hopkins (1935) the ratio of the volume of the colloid to the secretory epithelium increases as the secretory activity of the gland decreases. The principle function of thyroxin in warm-blooded animals is the regulation of metabolism. Since metabolism decreases by 25 to 30 per cent in most species when thyroid hormone is deficient (Fulton 1950) it can be assumed that the lethargy, lack of appetite and drooping posture of the experimental animals were, in part at least, due to this cause.

The great reduction in the size and weight of the ovaries of the birds after the removal of the anterior pituitaries indicates that normal function of these organs does not occur under conditions of deficiency of anterior pituitary hormones. Since all the experimental pullets were in a laying condition prior to the operation their ovaries must have been similar to those found in the normal birds. The lack of any mature ova in these ovaries indicates that the deutoplasm which had formerly accumulated within them had been resorbed. This observation is consistant with the reports of Hill et al., (1934) and Nalbandov and Card (1943). The microscopic structure of the normal ovarian follicle represents integrated functions of cells of various tissues which produce mature ova. The loss of this integration from follicles which are not influenced by anterior pituitary hormones indicates a regulation in which the hormones are involved. The specific nature of this regulation has not been demonstrated, but Fraps et al., (1942) were able to accelerate the formation and ovulation of mature ova in White Leghorn hens by intraperitoneal injections of follicle-stimulating hormone (FSH) and lutenizing hormone (LH), gonadotropic hormones of the anterior pituitary gland. That other factors are involved in ovulation was shown by Pearl and Surface (1916) when they failed to induce or augment ovulation in hens in which there was complete ovarian rest when they injected anterior pituitary extracts. The need for investigation of the hormonal regulation of ovarian function in the bird is apparent. Although a few studies report the effects of hormone deficiency on the avian ovary none was found which describes the microscopic structure of the ovarian tissue under these conditions.

The changes observed in the combs and wattles are attributed to the deficiency of ovarian hormones since investigators, who removed the ovaries, produced the same effects. The influence of ovarian hormones on secondary sex characteristics is also indicated by the rapid development of these structures at puberty. Latimer (1925) showed that the ovarian hormone estrogen is necessary for the maintainance of the comb and wattles.

The cause of death following hypophysectomy is not known; however, severe reduction of the level of blood glucose has been suggested by several investigators. Nalbandov and Card (1943) and Hill et al., (1934) showed that this low level of blood glucose in itself is not sufficient to cause death. They agree that death is due to drastic interference with metabloic processes, only one factor of which is the reduction of glucose in the circulation. Hill et al., (1934) suggest that the formation of glucose from endogenous protein does not take place in absence of estrogen. This factor was circumvented by preventing long intervals between

periods of eating in the hypophysectomized pullets used in this study as is suggested by Nalbandov and Card (1943). In a recent private communication Nalbandov expressed the opinion that if all extreme and rapid changes in the environment of an hypophysectomized hen are prevented, the animal should live out its normal life expectancy.

SUMMARY AND CONCLUSIONS

1. The removal of the anterior pituitary gland from White Leghorn pullets caused the thyroids and ovary to atrophy. Changes in behavior and external morphology resulting from this condition were lethargy, ruffled feathered coat, immediate cessation of ovulation and atrophy of the comb and wattles.

2. Changes in the structure of the thyroids are loss or reduction of the secretory epithelium, increased size of the colloids and loss of interstitial epithelium.

3. Changes in the structure of the ovary are resorption of deutoplasm from the developing ova and breakdown of thecal layers which surround the ova.

4. This study and other investigations indicate that a severe metabolic disturbance involving many factors is involved in the explanation of death following anterior pituitary ablation.

ACKNOWLEDGEMENT

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History of the Theories of Aether and Electricity. Volume II. *Sir Edmund Whittaker.* Philosophical Library, New York. 1954. xi+319 pp. $8.50.

This is the second volume of the most complete account to date of the subject. The first volume, covering the period up to 1900, was reviewed in the Journal last year (53: 180, 1953). The author intended to cover the first half of the 20th Century in one volume, but it now appears that two will be required, since the present work extends only to 1926. This is, of course, a most fascinating period in the history of electromagnetic theory covering, as it does, the discovery of Special Relativity, Quantum Theory, General Relativity, Matrix Mechanics, and Wave Mechanics. No one could be better qualified to give an account of the history of these subjects than the famous British scientist who has devoted the years since his retirement (at 73) from his position as professor of mathematics at Edinburgh mainly to historical studies. He is now 81, and is apparently carrying out his task with undiminished vigor. The current volume is a brilliant account of discoveries so recent that they have barely begun to be taught in present-day physics courses. Physicists and historians of science everywhere will eagerly await the appearance of Volume III; bringing the account up to virtually yesterday will require an Olympian detachment which few men would be capable of achieving more fully than the indomitable Sir Edmund.

CHARLES SUSSKIND

NEW MYRMECINAE FROM CENTRAL AMERICA
(COLEOPTERA, CURCULIONIDAE)

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The following new species of Myrmecinae were found during my studies of the afore mentioned group upon which a revision of the genera and species of the world will be forthcoming.

Myrmex cabimana n. sp.

Male.—Elongate, shining, black, clothed with fine white and black hairs, white hairs very sparse on elytra, denser on sides and apex.

Rostrum as long as pronotum, moderately stout, sulcate each side of middle, smooth along middle to apical third; clothed with fine white pubescence. Antennae black, segments of funicle elongate, oval, second slightly longer than third. Club elongate, densely pubescent with short, fine hairs, as long as preceding four segments.

Head smooth, shining, with sparse, fine punctures; a small elongate puncture on vertex, smooth between eyes. Eyes widely separated.

Prothorax obovate, sparsely clothed with fine, black and white hairs; disc finely, sparsely punctured, nearly impunctate on sides. Scutellum triangular, densely clothed with white setae.

Elytra elongate-oval, twice as wide as prothorax; humeri obliquely truncate; disc with very faint indication of striae and strial punctures, setigerous punctures of intervals very minute; finely clothed with black and a few sparse white hairs.

Ventral side and legs black, moderately clothed with fine white hairs, abdominal segments with radiate-pectinate scales on sides, finely, sparsely punctate. Femora elongate, slender, narrowly toothed, finely punctate. Anterior tibiae slender, straight, sinuate mesially at middle.

Length 5.2 mm., width 2.0 mm.

Type Locality.—Unique holotype, male, Cabima, Panama May 10, in collection of author.

Nearest *M. laevipennis* (Champion), but differs from *laevipennis* by larger size, black antennae (not "ferruginous"), and larger femoral tooth. *M. cabimana* has faint evidence of striae and strial punctures, while in *laevipennis* the striae and punctures are obsolete.

Myrmex championi n. sp.

Female.—Moderately elongate, shining, black, antennae reddish-brown; with a wide dense band of radiate-pectinate scales at base of prothorax and ventrally along margin of elytra from prothorax to hind margin of first abdominal segment; sparsely clothed with long erect black hairs.

Rostrum shorter than pronotum, smooth along median line, coarsely punctate laterally, finer at apex, a deep sulcus above each scrobe; sparsely clothed with long, white hairs. Antennae inserted in apical third; scape attaining eyes; funicle seven-segmented; first two segments elongate, remainder round, subequal in length. Club ovate, densely clothed with fine pubescence; as long as preceding four combined.

Head convex, with a few fine, distant punctures, vertex with a deep, round puncture. Eyes large, very convex, widely separated.

Prothorax obovate, longer than broad, sides rounded; finely, distantly punctate, punctures on sides obsolete, each puncture with a long, erect, black hair. Scutellum triangular, densely clothed with fine white pubescence.

Elytra long, convex, almost twice as wide as prothorax; striae unimpressed, strial punctures round, minute, distant, about five times their diameter apart; intervals flat, punctures of intervals fine, distant, each with a long, erect, black hair.

Ventral side strongly convex, sparsely clothed with white hairs, abdominal segments impunctate, fifth abdominal segment sinuate at apex. Legs elongate, moderately clothed with long, white hairs. Femora with a small, narrow tooth. Tibiae sinuate mesially, widest about middle. Tarsal claws divergent, minutely toothed.

Length 3.3 mm., width 1.4 mm.

Type Locality.—Unique holotype, female, Santa Clara, Costa Rica, XII-16, in collection of author.

Near *M. laevipennis* (Champion), a common species in Central America, but *championi* differs in the sulcate rostrum, strongly convex eyes, and band of pubescence at base of prothorax.

Ptinopsis floccosa Champion

Ptinopsis floccosa Champion, 1906, p. 724.

A single example of this species collected at Pariso, C. Z., Panama, II-6, in collection of author, was compared with the type of G. A. K. Marshall and declared conspecific. The type and, as far as I can ascertain, the only other known example of this species is very much abraded. With a passing glance this little weevil would be taken for a very beautiful ptinid. The type is from Cerro Zunil, Guatemala.

Ptinopsis panamensis n. sp.

Female.—Narrow, elongate, shining, dark reddish-brown; densely pubescent; pronotum with long, fine black hairs above, white radiate-pectinate scales laterally; elytra densely clothed with fine, long, black and white hairs, without radiate-pectinate scales, except behind scutellum on suture and few at declevity.

Rostrum short, thick, one-half length of pronotum; finely, densely punctate throughout, punctures nearly obscured by vestiture. Antennae light reddish-brown, each segment from 2–7 wider than preceding, second twice as long as third. Club elongate, oblong, densely, finely pubescent.

Head closely, finely punctate, punctures obscured by narrow scale-like white setae. Eyes nearly flat, narrowly separated (less than one-fifth diameter of eyes).

Prothorax obovate, swollen apically, constricted basally; finely sparsely punctate, densely clothed with fine, long black and shorter white hairs, with a large tuft of black hairs at middle. Scutellum densely pubescent with white, radiate-pectinate scales.

Elytra elongate, sides subparallel; humeri obliquely truncate; punctures of striae fine, both strongly impressed, less so at sides; intervals slightly convex, confusedly, finely punctate; densely clothed, except apical third, with long, fine, black hairs, apical third with long, fine, white hairs with a few intermixed radiate-pectinate scales.

Ventral side sparsely clothed with fine, white radiate-pectinate scales; abdominal segments reddish-brown, shining, finely, sparsely punctate; second segment longer than third, last as long as third and fourth combined. Legs densely clothed with long, fine, white hairs intermixed with white radiate-pectinate scales. Anterior femora short, thick; densely, coarsely punctate, unarmed. Anterior tibiae short, thick, feebly sinuate mesially, widest before middle; densely, coarsely punctate. Anterior tarsi reddish-brown, as long as tibiae.

Length 2.9 mm., width 1.3 mm.

Type Locality.—Unique holotype, female, Porto Bello, Panama, III-1, in collection of author.

Resembles *P. floccosa* Champion, however, *floccosa* differs as follows: striae and punctures not as deeply impressed, anterior tibiae straight within, radiate-pectinate setae of elytra condensed into three irregular transverse fasciae (*panamensis* clothed with long black hairs on basal two-thirds, apical third clothed with long white pubescence intermixed with radiate-pectinate white scales); *floccosa* lacks the prominent tuft of black pubescence on pronotum.

Oopterinus championi n. sp.

Female.—Elongate, shining, reddish-brown with a brassy luster, underside, legs, and antennae reddish-brown; elytra sparsely clothed with long, fine, brownish-white hair.

Rostrum longer than pronotum, slender, rugosely punctate-striate, scrobes diverted beneath in basal third. Scape of antennae reaching forward margin of eye; segments of funicle elongate, second twice as long as third. Club obovate, densely pubescent, as long as preceding four segments.

Head smooth, shining, with distant, coarse punctures. Eyes separated by more than half their diameter.

Prothorax obovate, sides strongly arcuate, smooth, shining, sparsely, minutely punctate, punctures with very fine, short, black hairs. Scutellum not visible.

Elytra elongate-oval; humeri obsolete; striae finely punctured throughout, punctures nearly obsolete; intervals flat, impunctate; sparsely clothed with long, fine, brownish-white hair.

Ventral side and legs sparsely clothed with fine white hairs. Ventral segments of abdomen with distant irregular sized punctures, last segment longer than preceding two. Anterior femora moderately thick; minutely dentate, remainder not dentate. Anterior tibiae slender, straight mesially.

Length 3.4 mm., width 1.2 mm.

Type Locality.—Unique holotype, female, Real de Arriba, Temescaltepec, Mexico, VI-11-33, Alt. 8000 ft., in collection of author.

Nearest to *O. gibbipennis* Champion from Guatemala, however, *gibbipennis* is clothed with rather long sparse recumbent, white setae; head with close, coarse punctures; rostrum shorter, stouter, more closely punctate; pronotum coarsely punctate, with a long, smooth area on the sides; elytra broader, much more convex, longitudinally and steeply declivous behind, with strongly punctate lateral striae.

Oopterinus convexipennis n. sp.

Short, ovate, black, feebly shining, vestiture lacking.

Rostrum one-fourth shorter than pronotum, coarsely punctate on sides, with a narrow, smooth, median line. Antennae dark reddish-brown, scape attaining eyes, segments of funicle elongate, second twice as long as third, 3 to 6 equal in length. Club elongate, oval, densely pubescent, longer than preceding five.

Head smooth, feebly shining, with distant coarse punctures, smooth and flat between eyes; deeply sulcate over eyes. Eyes separated by more than half their diameter.

Prothorax obovate, strongly constricted basally, shining, with distant, fine punctures, coarser on sides. Scutellum small, rounded, densely pubescent.

Elytra moderately elongate, strongly inflated behind middle; humeri absent; surface of elytra smooth, punctures and striae obsolete, vestiture lacking.

Ventral side and legs without vestiture, first two segments finely, distantly punctate, remaining segments finely, distantly punctate, alutaceous basally; last segment longer than preceding two. Femora elongate, thick anteriorly, minutely dentate, basal half with narrow, white, scale-like setae. Tibiae short, robust, strongly sinuate mesially, widest part before middle.

Length 2.8 mm., width 1.0 mm.

Type Locality.—Unique holotype Porto Bello, Panama, III-7, in collection of author.

Nearest to *O. bactrians* Champion from Tepa in Tabasco, Mexico, which differs in having the prothorax less globose in front, less convex dorsally and less abruptly narrowed at the base; elytra longer and less convex longitudinally.

Erodiscus hamburgi n. sp.

Female.—Elongate, shining, black; elytra only sparsely clothed with long, erect, white, bristly hairs on intervals 2, 4, and 6.

Rostrum slender, not thickened basally, little more than half as long as body, finely, densely punctate in basal two-thirds, rugose laterally, feebly sulcate above scrobes, median line smooth. Antennae inserted beyond middle; segments elongate, club-shaped, second segment slightly longer than third; club elongate-oval, densely pubescent.

Head smooth, shining, with very minute, distant punctures, smooth between eyes, front with a small deep puncture. Eyes widely separated above.

Prothorax longer than wide, very convex; sides strongly rounded, subparallel basally, feebly constricted apically; with fine distant punctures dorsally, coarser laterally. Scutellum elongate, rounded behind.

Elytra elongate, sides subparallel, inflated behind middle; humeri obtuse; strial punctures minute, distant, three times diameter apart; setiferous punctures of intervals much larger than punctures striae.

Ventral side without vestiture; prosternum coarsely, deeply punctate in front of coxae; first and second segment of abdomen very convex, suture not in evidence; first to fourth segments smooth, impunctate, fifth coarsely punctate laterally, smooth at middle. Femora with a small narrow tooth. Anterior tibiae feebly arched within, widest at middle. Tarsal claws simple.

Length 3.6 mm., width 1.1 mm., rostrum 2.2 mm.

Type Locality.—Unique holotype, female, Reventazon, Costa Rica, VI-24, E. Hamburg collector, in collection of author. According to Champion (1903) it will key to *E. angustatus* Champion. However, it is nearest *E. bituberculatus* Champion. The latter differs in having the eyes closer; rostrum with a deeper, lateral sulcus; prosternum with no punctures in front of the coxae.

Erodiscus marshalli n. sp.

Male.—Elongate, shining, dark reddish-brown throughout; intervals 2, 4, and 6 each with very long, erect, whitish hairs.

Rostrum about twice as long as pronotum, distinctly thickened toward base, basal third rugosely punctured laterally with narrow, smooth median line. Antennae inserted slightly beyond middle; second segment slightly longer than third. Club oval, densely pubescent.

Head smooth above eyes, between eyes densely, coarsely punctured with wide median line. Eyes widely separated above.

Prothorax longer than wide, strongly convex, sides strongly rounded, base subcylindrical, apex abruptly constricted; coarsely punctured throughout with a narrow, smooth area at middle. Scutellum minute, narrow, rounded posteriorly.

Elytra elongate, as wide as pronotum, sides subparallel in basal half; punctures of striae fine, distant, setiferous punctures on intervals very minute.

Ventral side and legs without vestiture; first and second segments convex, smooth, fused, suture obsolete, third, fourth and fifth segment very coarsely punctate; fifth segment with a shallow depression at middle. Anterior tibiae very feebly sinuate within. First tarsal segment nearly as long as remainder combined; tarsal claws simple.

Length 2.3 mm., width 0.8 mm., rostrum 1.3 mm.

Type Locality.—Unique holotype, male, Barro Colorado Island, C. Z., Panama, VI-10, in collection of author.

Keys in Champion (1903) to *E. laevigiatus* Champion to which it is closely related. Compared with type of *laevigiatus* and differs from the latter by abruptly constricted and more densely, coarsely punctate prothorax.

Erodiscus panamensis n. sp.

Female.—Elongate, shining, dark reddish-black throughout, antennae reddish-brown; prothorax, legs and even intervals of elytra sparsely clothed with long, erect, white, bristly hairs.

Rostrum twice as long as pronotum, thickened basally; basal half finely punctured, coarser laterally, apical half smooth. Antennae inserted behind middle, segments elongate, slender, second segment one and one-half times longer than third. Club elongate, oval, densely pubescent.

Head smooth with a shallow fovae between eyes. Eyes very close above.

Prothorax much longer than broad, very convex, strongly rounded at sides, constricted apically, subcylindrical basally; apical and basal constriction strongly, coarsely punctured, remainder smooth, shining, finely punctate. Scutellum small, round.

Elytra elongate, slightly wider than pronotum strongly constricted at base in front of humeri, subparallel in basal half, slightly produced apically; humeri obtuse; punctures of striae moderately

fine, about twice diameter apart, striae strongly impressed laterally; intervals flat, setiferous punctures larger than those of striae.

Ventral side without vestiture, first and second abdominal segments smooth, strongly convex, apparently fused, suture between very feeble, but in evidence, third and fourth segments smooth, fifth with a few distant, shallow, coarse punctures, without shallow impression. Anterior femora with a prominent tooth, remainder minutely dentate. Anterior tibiae strongly arched at middle mesially, remainder nearly straight. Tarsal claws with a short, fine tooth.

Length 5. 2 mm., width 1.6 mm., rostrum 3.7 mm.

Type Locality.—Holotype, female, Porto Bello, Panama, III-12, one paratype, Porto Bello, Panama, III-1, in collection of author.

Nearest to *E. bituberculatus* Champion, however, the latter has a shorter rostrum with a deep lateral sulcus above the scrobe; funicular segments are much shorter and more club-shaped; prothorax lacks strong punctures on basal and apical constrictoins; elytra not produced at apex and with no lateral striae.

Erodiscus sharpi n. sp.

Female.—Elongate, shining, black, tip of rostrum, femora proximally, and tarsi reddish-brown, elytral striae prominent.

Rostrum short, nearly twice as long as pronotum, thickened at base, narrowly carinate at middle; coarsely, closely punctate laterally, finer at apex. Antennae inserted at apical third. Funicle seven-segmented, second segment longer than third, remainder subequal in length. Club ovate, densely, finely pubescent.

Head convex, finely alutaceous, finely, sparsely punctate. Eyes large, flat, narrowly separated.

Prothorax obovate, longer than broad, strongly convex, sides rounded, not constricted apically; pronotum alutaceous, with fine, distant, fusiform punctures. Scutellum minute, narrow-elongate.

Elytra one-third wider than pronotum, sides divergent from base to just behind middle, thence convergent to apex; humeri feebly rounded, nearly obsolete; striae deeply impressed, very narrow, strial punctures distant, very minute, nearly invisible; intervals flat, impunctate.

Ventral side strongly convex, smooth, finely alutaceous. First and second abdominal segments fused, suture obsolete; fifth segment as long as third and fourth. Legs elongate, femora minutely dentate, anterior tibiae sinuate mesially, broadest at middle. Tarsal claws simple.

Length 3.0 mm., width 0.9 mm., rostrum 1.3 mm.

Type Locality.—Unique holotype, female, Porto Bello, Panama, II-20, in collection of author.

Near *E. angustatus* Champion from Guatemala, which is dark reddish-brown, striae not impressed, has even intervals with minute punctures and long, erect whitish hairs. With the exception of *E. sharpi* all other Central American members of this genus have alternate intervals of elytra with erect vestiture, no others have striae deeply impressed.

Named for Dr. David Sharp in recognition of his great work on Central American Rhynchophora.

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THE MEIGS CREEK COAL "LOWER SPLIT" IN SHORT CREEK TOWNSHIP, HARRISON COUNTY, OHIO

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The unweathered exposures on the highwalls of a large number of extensive strip pits in Short Creek Township, Harrison County, Ohio offer unusual opportunities to study the stratigraphy of the Monongahela Series (Upper Pennsylvanian) in great detail. The township is located in the extreme southeastern corner of Harrison County and is about 20 miles southwest of Steubenville. This paper summarizes some of the results of intensive study of these rocks by the writer in August 1953 under the auspices of the Geological Survey of Ohio and is intended merely as a factual presentation of stratigraphic data with no implications concerning cyclic sedimentation.

PREVIOUS INVESTIGATIONS

Until the summer of 1953 the stratigraphy of the Monongahela Series in southeastern Harrison County had not been studied except by reconnaissance methods. Detailed work in this area was first undertaken by Condit (1912) when he reported on the underlying Conemaugh Series in Ohio. Then Lamborn (1930) described the Monongahela Series in Jefferson County which adjoins Short Creek Township on the east. As recently as 1947 White described the Waynesburg coal and its stratigraphic relations in Harrison and northern Belmont Counties.

NOMENCLATURE

In Short Creek Township the stratigraphic section between the Fishpot and Meigs Creek coals is of particular interest since it contains a persistent coal horizon that in the past has been overlooked (Stout, 1930, 1939, 1947) or possibly confused with the Fishpot coal not only in the field but in the literature as well. Since this coal bed is known to underlie large areas in both Harrison and Belmont Counties, the writer believes that it is an essential part of the standard stratigraphic section for Ohio and in the future should be recognized as such.

The regional relations of this additional coal horizon are as yet uncertain but there is considerable evidence that the interval between it and the Meigs Creek coal decreases toward the west and south from Short Creek Township. The "new" bed thus appears to be a split from the Meigs Creek coal and therefore, has been tentatively referred to as the Meigs Creek coal "Lower Split" by some members of the Geological Survey of Ohio. Since the cyclic relations of this bed are not known and the stratigraphic nomenclature for the rocks of the Pennsylvanian System is so unsettled, the writer is of the opinion that the name "Lower Split" is as descriptive as any. To propose an entirely new name would simply add to the confusion.

STRATIGRAPHY

In general the Meigs Creek coal "Lower Split" in Short Creek Township is a black, moderately fissile, thin-bedded shale from 4 to 10 in. thick. The sequence of strata both above and below the black shale is dominantly fine to coarse clastic sediments forming variable amounts of gray to brown shale, siltstone and sandstone.

Since the coal beds are the most persistent units of the Monongahela Series in eastern Ohio the best method to describe the stratigraphic position of the Meigs

Creek coal "Lower Split" is to note its relation to the adjacent named coal beds. In Short Creek Township the average of six measured stratigraphic sections including the thickness of the interval between the underlying Fishpot coal and the "Lower Split" is 31ft.; the range is 27 to 38 ft. Similarly, the average of seven sections of the interval between the "Lower Split" and the base of the overlying Meigs Creek coal is 14 ft.; the range is 11 to 17 ft. (table 1). In the same area the "Lower Split" is 61 to 92 ft. above the base of the Pittsburgh coal and 43 to 67 ft. above the Redstone coal.

TABLE 1

Generalized stratigraphic section of the Monongahela series in Short Creek Township showing the relationship of the Meigs Creek coal "lower split" to other named units

Lithology	Thickness in ft.
Coal, bright, blocky. *Waynesburg*	4
Sandy shale and sandstone. *Uniontown-Gilboy*	21–41
Coal and black shale. *Uniontown*	1
Shale, sandstone, and limestone	42–50
Interbedded green shale and gray limestone. *Fulton*	2–10
Limestone, argillaceous, gray, soft. *Benwood*	30–50
Shale and sandstone, brown to gray	10–15
Coal, bright, blocky. *Meigs Creek*	2–5.25
Sandy shale and sandstone	11–17
Shale, black. *Meigs Creek coal "Lower Split"*	0.33–0.8
Sandy shale and sandstone	27–38
Shale, black. *Fishpot coal horizon*	0.67–0.9
Limestone, argillaceous, gray to tan. *Fishpot*	24–36
Coal and black shale. *Redstone*	0.5–2
Claystone and limestone. *Redstone limestone*	20–32
Coal, bright, blocky. *Pittsburgh*	5

There is a very accesible exposure of the Meigs Creek coal "Lower Split" and the intervals to the Fishpot and Meigs Creek coals on the highwall of an abandoned strip pit just south of U. S. Highway No. 250 in the extreme northeast corner of the SW¼, Section 26 of Short Creek Township. These same coals are also well exposed in the road cut above the highwall in the SE¼, NE¼, Section 15 and on the highwall in the SW¼, NE¼, Section 13 of the same township.

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NEW MYRMECINAE (COLEOPTERA, CURCULIONIDAE) FROM THE ANTILLES

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The following forms new to science were discovered by the author while preparing a revision of the Myrmecinae of the World. The author is indebted to Mr. J. A. Ramos, University of Puerto Rico, Mayaguez; Mr. Mont Cazier and Mrs. Patricia C. Vaurie both of the American Museum of Natural History, New York, for the material collected by them.

Micromyrmex insularis n. sp.

Female.—Elognate, subcuneate; black, with antennae, head, basal fifth of elytra, meso-and metasternum, base of femora, and tarsi pale reddish brown, and the prothorax, femora, and tibiae dark reddish brown; very sparsely clothed with long, erect coarse, white setae.

Rostrum five-eighths as long as pronotum with coarse rugose punctures laterally, and a broad smooth, impunctate area dorsally extending from base to apex. First segment of funicle robust, one-half longer than second; second to seventh subequal. Head convex, smooth very sparsely and coarsely punctured; a prominent supraocular ridge extending longitudinally from eyes to apical margin of prothorax; a transverse groove extending laterally behind eyes; front smooth, impunctate. Eyes small, convex, separated by three-fourths their diameter.

Prothorax prominently obovate, strongly constricted basally but not constricted apically, sides feebly rounded; pronotum very sparsely, finely, almost obsoletely punctate in basal two-thirds, punctation coarser and denser apically; flanks finely, sparsely punctured. Scutellum large, triangular, densely clothed with white vestiture.

Elytra as wide at base as pronotum, strongly inflated behind, widest at middle; humeri rounded; striae not impressed, strial punctures very minute, fusiform, about twice their length apart; intervals very flat, with a few scattered punctures which are larger than the strial punctures, each bearing a long, erect, coarse, white seta.

Ventral side with prosternum sparsely, coarsely, and shallowly punctured, remainder of ventral side smooth and impunctate, sparsely clothed with fine semierect white setae. Legs long and slender. Anterior femora with a very minute denticle. Inner margin of anterior tibiae straight with a row of minute denticles. Claws prominently toothed.

Length 2.6 mm., width 0.75 mm.

Male.—Unknown.

Material examined.—Holotype, ♀, Andros Island, Bahamas, B. W. I. VI–52, in the author's collection.

Nearer *Micromyrmex poeyi* (Chevr.) than *Micromyrmex pulicaria* (Boh.) (new combination), differing from *poeyi* in the smooth median area of the rostrum, the smoother and more sparsely punctured head, the stronger and more prominent supraocular ridge, the finer punctures of the prothorax, the much finer punctures of the elytral striae, and the absence of a broad shallow fovea on the front.

Erodiscus tinamus cazieri n. ssp.

Male.—Elongate, convex; shining, intense black, the antennae, tarsi, tibiae, and rostrum dark reddish brown; prothorax and elytra with sparsely placed erect white setae which are arranged on elytral intervals 2, 4, and 6.

Rostrum two-thirds as long as body, moderately arcuate, densely punctured in basal two-thirds, apical third smooth and impunctate, a smooth median line present in basal two-thirds. Head convex, sparsely and minutely punctate; front not foveate. Eyes separated by slightly more than half the width of the apex of antennal scape. Second segment of funicle nearly twice as long as first.

Prothorax strongly globose, sides strongly curved; basal constriction very short, deeply punctured and alutaceous; apical constriction feeble with coarse, irregular punctures; pronotum with sparse, fine, elliptical, shallow punctures; flanks with coarse, deep elliptical punctures. Scutellum small, rounded.

Elytra as wide as pronotum, two and one-half times longer than wide, feebly constricted at base; sides evenly rounded; humeri feeble, oblique; striae not impressed, strial punctures coarse, moderately deep, each containing a minute, narrow, depressed scale; intervals 2, 4, and 6 with a few widely separated, coarse punctures.

Ventral side with thoracic sterna coarsely, deeply, densely punctured, lateral areas of first and second and all of the remaining segments sparsely, coarsely, deeply punctured; middle of first and second segments smooth, impunctate; first segment with a prominent tubercle; fifth segment with a large, median, round, finely, densely punctured depression. Legs elongate, strongly clavate. Anterior femora with a prominent acute tooth. Anterior tibiae feebly sinuate mesally. First tarsal segment nearly as long as remaining tarsal segments. Claws with a minute tooth.

Length 6.0 mm., width 1.75 mm., rostrum 4.25 mm.

Female.—Rostrum two-thirds as long as body; first abdominal segment without a prominent tubercle, otherwise very similar to male. Length 5.25 mm., width 1.7 mm., rostrum 3.75 mm.

Material examined.—Holotype, ♂, South Bimini Island, Bahamas, B. W. I., VI–18–50, Cazier & Rindge; allotype, ♀, same data, both in the Entomological Collection, the American Musuem of Natural History. Twenty-eight paratypes which, unless otherwise noted, are all from South Bimini Island, Bahamas, B. W. I., deposited as follows: in the American Museum of Natural History, 1 ♂, 1 ♀, VI–13–50, Cazier & Rindge; 1 ♂, 1 ♀, VI–18–50, Cazier & Rindge; 1 ♂, VI–19–50, Cazier & Rindge; 1 ♂, 3 ♀, V–51, Cazier & Gertsch; 1 ♂, VI–51, M. Cazier, C. & P. Vaurie; 3 ♀, VII–20/31–51, C. & P. Vaurie; 1 ♂, VIII–2/9–51, C & P. Vaurie; 1 ♀, VIII–8–51, C & P. Vaurie; 1 ♂, 1 ♀, VIII–10/20–51, C. & P. Vaurie; 1 ♀, North Bimini Island, Bahamas, B. W. I., VI–51, M. Cazier, C & P. Vaurie; in author's collection, 1 ♂, VI–13–50, Cazier & Rindge; 1 ♂, 1 ♀, VI–18–50, Cazier & Rindge; 2 ♂, 2 ♀, V–51, Cazier & Rindge; 1 ♂, VII–28–51, C & P. Vaurie; 2 ♀, VIII–29–51, C. & P. Vaurie. Length of paratypes 4.5–6.6 mm., width 1.4–2.0 mm., rostrum 3.0–4.5 mm.

Very similar to *Erodiscus tinamus tinamus* Le Conte, differing in the finer, smaller, more shallow pronotal and lateral punctures of the prothorax, the smoother more finely punctured head, the more intense black color of the body, and dark reddish brown legs.

Erodiscus ramosi n. sp.

Male.—Elongate, strongly convex; shining, intense black, with antennae, apical third of rostrum and last tarsal segment dark reddish brown; very sparsely clothed with widely separated long erect white setae.

Rostrum three-fifths as long as body, slightly arcuate, densely confluently punctured in basal two-thirds, smooth very minutely punctate apically; a very narrow median carina dorsally in basal two-thirds. Heads shining, finely alutaceous. Eyes separated by much more than one-half the width of the antennal scape at apex. Front with a very feeble, narrow groove.

Prothorax very globose, strongly rounded on sides; base strongly constricted, sparsely, deeply punctured, strongly alutaceous; apex feebly constricted, very deeply, irregularly punctured; pronotum very sparsely, deeply, coarsely punctured; flanks very coarsely, deeply punctured, finely alutaceous. Scutellum small, ovate.

Elytra nearly twice as long as wide, not constricted basally, sides evenly arcuate to apex; humeri effaced; striae unimpressed, strial punctures very large, deeply impressed, on disc cutting deeply into intervals; intervals feebly convex, with a few distant minute punctures each with an erect white seta.

Ventral side coarsely, deeply punctured; abdominal segments punctured laterally, smooth, impunctate at middle; first abdominal segment with a prominent tubercle; fifth segment with a small feeble round depression at middle. Anterior femora with a small acute tooth, remaining femora unarmed. Anterior tibiae feebly sinuate, broadest at middle. Claws armed with a minute tooth.

Length 4.6 mm., width 1.4 mm., rostrum 2.75 mm.

Female.—Unkown.

Material examined.—Holotype, ♂, Colonia Ramfis, R. D. (Dominican Republic), IV–3–53, J. A. Ramos. One paratype, ♂, same data. The holotype (# 62303) in the United States National Museum, the paratype in the author's collection. The paratype differs from the holotype in that the pronotum is obsoletely punctured. Length of paratype 4.75 mm., width 1.5 mm., rostrum 3.0 mm.

This species is unlike any other in appearance, but seems to be nearer *Erodiscus tinamus tinamus* LeConte from which it differs in the much coarser, sparser punctation throughout, except on rostrum which is more finely punctured, the absence of a constriction at base of elytra and the absence of femoral teeth on middle and hind femora.

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